ILLUMINATING ENGINEERING

AUGUST 1952

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Some Applications of Store Lighting Principles
Appraisal Unit for Men's Clothing Stores
Colleges Offering Illumination Courses
Street and Highway Lighting Practice
Visual Effectiveness of White Lights
Observations on Store Lighting
Light Depreciation Survey

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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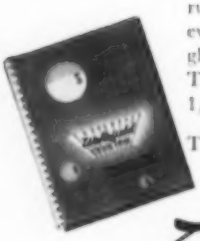

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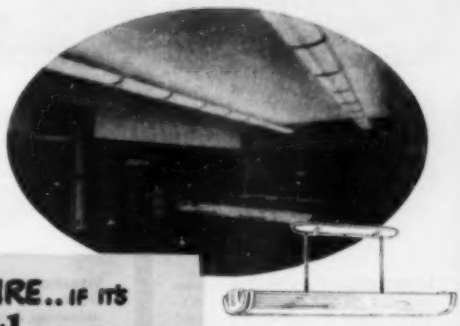

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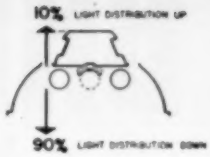

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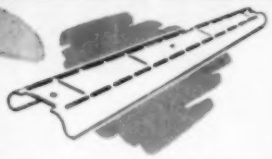

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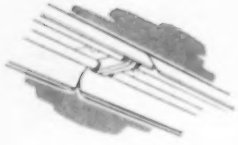

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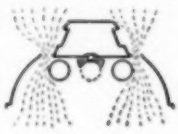

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ILLUMINATING ENGINEERING

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CHICAGO IN '52

Observations on Today's Store Lighting

By W. S. FISHER

THE LIGHTING industry geared-up during the post-war period to supply the merchandising world with planned store lighting. In the period from 1946 through 1950 great progress was made in providing new luminaires, equipments, and light sources to fit the modern concept of store lighting. In this concept light is a primary factor in many phases of merchandising. It helps to utilize effectively all the appointments and components of an establishment and, at the same time, makes a powerful contribution to selling. Merchants everywhere have embraced this idea of using light for specific functions, and many store owners rate lighting for selling at the top of their modernization list.

In the last two years the development of equipment for this field has largely given way to that more essential to the mobilization effort. Industrial lighting has had the major emphasis, which is as it should be. Still, the momentum that was built up in the 1946 to 1950 period has carried along in the store field to the present. Indeed, some of the most promising developments occurred late in that period and have only recently been applied extensively.

During the war period fluorescent lighting was not sufficiently available to stores to meet the growing demand. It was well regarded by most merchants because of its unique functional characteristics. Fluorescent lamps produced cool footcandles at high efficiency and gave soft shadows and low-brightness highlights. Their physical dimensions made them well suited for application in luminous elements and for many forms of display, especially perimeter and valance lighting.

Today, many stores are relying on fluorescent lamps for a large proportion of their general lighting with filament lamps added to the system for the creation of highlights and for spotlighting. Fluorescent used alone sometimes results in a flat, uninteresting environment. Filament sources can add sparkle, modelling, warm color, and the stimulating atmosphere of a sunny day. Two-component lighting has properties that generally provide the best all around appearance of merchandise, which varies so widely in size, form, texture, and color. Dual lighting is firmly established as a basic technique.

There exists a spirit of competition among merchants and designers for the unusual and the distinctive in lighting. Notable examples are found where a complete job has been done with filament downlighting. Very often the filament units are the well-shielded type that provide low brightness in the upper zone of the store. These often incorporate the PAR-38 and R-40 spot and flood lamps. Here is an application for sources whose rise in popularity parallels that of fluorescent lighting in the store field.

To reveal the inherent character of an article, filament lamps may best serve in one instance, fluorescent in another. In a practical sense, if attention is centered only on supplying the quality of lighting appropriate for specific articles or ensembles throughout a store, the result may be unsatisfactory due to lack of coordination. The specifics must be superposed on a background scheme taking account of traffic flow, display layout, scale of lighting equipment, and an overall brightness pattern to create the desired selling environment. It is feasible and often highly effective to vary the light source, the equipment, and the layout from one section to another.

The variety of equipment available today and the innumerable possible combinations afford opportunity for originality in system design together with sound, functional planning and good engineering.

Fig. 1 demonstrates the use of equipment occupying only a small percentage of the ceiling area applied to produce a distinctive effect. By contrast, Fig. 2 shows an area where the entire ceiling is used to furnish the lighting which is agreeable, in part, because of the acoustical baffles. The installation supplies 100 footcandles in service for general sales illumination. Many merchants, thinking ahead in their plans, are installing lighting of this magnitude and finding it a good investment.

Other stores are employing lighting patterns somewhere in between the two extremes just described. For example, the louverall and luminous ceiling techniques are often modified by arranging

(text continued on page 415)

AUTHOR: Application Engineering Dept., General Electric Co., Nela Park, Cleveland, Ohio.

Figure 1. In this remodelled store a tropical atmosphere is obtained by careful choice of all the materials and elements. The green planting, grass mats, and bamboo, represent jungle growth. Well-louvered 150-watt PAR-38 spot and floodlamps contribute strong highlights and deep shadows as if sunlight were filtering through dense foliage overhead. The illumination on displays is from 100 to 150 footcandles.

Figure 2. This luminous ceiling occupies nearly the whole ceiling area and supplies 100 footcandles. Variety in brightness pattern is achieved with the acoustical baffles on the ceiling, with downlighting at the perimeter of the room, and with several forms of display lighting. This I.L.E. Gold Seal Award winner was designed by H. L. Nichol with L. R. Nall of Detroit.

Figure 3. These 6 x 24-ft. louvered panels using slimline fluorescent lamps help set the scale in this space. The lighting layout is varied for interest, and for emphasis in certain departments.

Figure 4. Another luminous element — this time a standard luminaire — is arranged in a uniform layout for distribution of light and for appearance. Incandescent downlights of low brightness in the direction of the eye are added to provide a combination lighting system of excellent quality. Forty footcandles are supplied — approximately 25 per cent by the incandescent units.

Figure 5. Lighting for atmosphere and for emphasis of architectural features is important in establishing the mood of this millinery salon. A combination lighting system of incandescent downlights and fluorescent coves blends sources for a good final result. In the downlights 100-watt general service lamps supply highlights, sparkle and modelling, and two rows of 96T8 de luxe warm white fluorescent lamps in each side of the cove soften shadows. Appearance of materials and complexions is improved with this dual system. Cool white fluorescent lamps are used for contrast in the wall displays. The average lighting level is 35 footcandles.

Figure 6. Indicative of one trend in luminaire design, this unit for 8-foot slimline fluorescent lamps is wider as well as longer than older types.

Figure 7. Sometimes a circular element is adopted to play a part in a particular design. This round unit employs eight 20-watt fluorescent lamps in the louvered section and a 300-watt incandescent lamp in a polished reflector in the center.

Figure 8. Side-shielded luminaires are being installed in many high-traffic stores. They give a more finished appearance in keeping with the rest of the store.

Figure 9. This valance is typical of recent good design in supermarkets. Extension brackets project the unit 30 inches from the wall where the utilization of light on display surfaces is better. Two rows of fluorescent lamps are concealed in the lower part for lighting merchandise. A third row of lamps above lights a background for silhouetting department signs and brightens the ceiling.

Figure 10. At Kennedy's, in the new shopping center at Framingham, Mass., slimline fluorescent lamps in the de luxe cool white color are used: the arrangement of luminaires in lines and geometric patterns gives emphasis to the several selling areas; architectural features are emphasized with cove lighting and perimeter lighting; and several display lighting techniques are used.

(text continued from page 411)

large lighting elements on regular spacings as shown in Figs. 3 and 4. Some advantages of this plan are: The ceiling area has more variety in pattern; the element size and shape can be chosen to fit the space; the layout may be designed for greater architectural emphasis in a given area; and filament downlighting may be included in the elements or in a separate related arrangement. In Fig. 5 large fluorescent-lighted coffers are used to this end with marked effectiveness.

An interesting trend in standard fixture design is also noted. Many of the new luminaires, particularly those for slimline fluorescent lamps, are wider than previous models as shown in Fig. 6. The proportions are more in scale with many store interiors. Larger elements can be created simply by putting two or more units of this type side by side.

There are times when circular elements are chosen for design reasons; see Fig. 7. For this first floor a round element about 3½ feet in diameter was selected. In order to use fluorescent sources of required light output per foot, standard hot cathode lamps of the shorter length were chosen. Maintenance is increased since there are more lamps in the system for the same illumination. Group replacement of lamps is advisable for such equipment. In larger-diameter elements, the longer, more efficient fluorescent lamps could be utilized to advantage. The units shown in the illustration incorporate a filament downlight producing about one-third of the total lumens.

Another interesting lighting development is noted in the high-traffic store field. The food and drug types often have set the pace in their locality for the illumination values used. They want a stimulating "open-for-business" atmosphere, and high footcandle levels contribute much to that feeling. To the same end, many high-traffic stores use exposed fluorescent lamps. Merchants like the wide distribution which does a good job of lighting the vertical surfaces of merchandise displayed in wall cases and shelving.

Other store people find bare lamps excessively bright, competing with the merchandise for a shopper's attention. Many merchants desire a more finished appearance for their ceiling lighting. Equipment which modifies the distracting and uncomfortable effects of exposed lamp systems yet retains some of their desirable characteristics may be the answer to this problem.

Recently fixtures with side shielding have been used in some grocery and hardware stores as shown in Fig. 8. These units have plastic or glass side panels, a deep "V" channel between lamps, but no lengthwise shielding. Maintenance is about as easy as with the exposed-lamp types since there are no louvers to remove when changing lamps and only smooth, unobstructed surfaces to clean. The luminous side panel contributes to a stimulating atmosphere and the store interior appears bright and attractive from the street.

In another example of progress for the high-traffic field, some supermarkets are today exhibiting a conspicuous improvement in the valances they use for display lighting. The improved design builds up the brightness at the perimeter of the store, which makes the merchandise more attractive, lights departmental signs, influences traffic flow, and gives the effect of greater spaciousness. Accomplishing these multiple functions effectively calls for two or three continuous rows of fluorescent lamps instead of the usual one. At the same time it also requires better engineering design to realize the full benefits. In order to utilize the light more effectively, these valances are projected 30 to 36 inches out from the wall on extension brackets, instead of the typical cramped, close-to-wall mounting. This permits more uniform distribution of light from top to bottom of a display and a smoother gradation of brightness on the upper wall and ceiling. An example is shown in Fig. 9.

There is a pronounced trend to slimline fluorescent, especially the 96T12 lamp for new lighting installations. One reason is simplified maintenance as a result of fewer parts in the system for the same amount of light.

There is a growing use of deluxe cool and warm white fluorescent lamps. Starting slowly, their application is accelerating due to the highly favorable experience reported by more and more users.

Fig. 10 shows a modern store incorporating in one fairly small area several of the techniques discussed. The lighting for the balcony consists of lines of light. The large open squares emphasize the high ceiling space. Slimline fluorescent in deluxe cool white is the main light source. Filament spotlighting, display fixture lighting and lighting for architectural emphasis give variety to the brightness pattern. Modern design, attractive finishing materials and the appropriate use of color are combined in the ensemble.

Although basic store lighting principles are well established, the field is by no means a static one. The merchant, the architect, the engineer and the designer are constantly evolving new practices, which contribute further to store sales and profits.

Smaller Cities Leaders In

←

Albert Lea, Minnesota — Remodeling plans for this sales floor (upper left) of an old building included several well-known restrictions, but especially financial limitations which allowed for no structural changes. Since it was not possible to lower the 18-ft ceiling, the new lighting system was related to the building lines. The lighting design of 4-ft square recessed panels, 8-ft and 4-ft fluorescent luminaires, plus accent spotlights, was laid out to conform to the ceiling bay construction and to take advantage of the natural shielding afforded by the deep beams. Spotlights serve a two-fold purpose of relieving monotony of lighting "tone" and effectively highlighting displayed merchandise. Surface brightnesses are carefully balanced. Illumination levels obtained were 75 ft-c general lighting with 120 to 162 ft-c under the spotlights focused on the displays. The installation won a Merit Award for George Simpson, Interstate Power Co., Albert Lea, Minn.

La Jolla, California — High level lighting with comfortable brightnesses makes this jewelry store the talk of the town (below). A level of 190 ft-c is provided over the showcases; general lighting is 115 ft-c. Surface colors are light blue of high reflectance. Luminaires are 4-lamp 430 ma T12 slimline, plus a battery of 40 adjustable units using 150-watt R-40 spot lamps. The installation won a Merit Award for D. F. Curtis, San Diego Gas & Electric Co., San Diego, Calif.

↑

Miles City, Montana — Western hats, saddles and levis require appraisal-selling aids too (above). In Furstnow's Western Wear Store, all the techniques of balanced brightnesses have been applied in the relighting project. The ceiling was refinished with white insulating cane board; walls were repainted nile green of high reflectance; wooden floors were covered with red and cream colored tiles. Eighteen fluorescent luminaires having translucent plastic sides and louvered bottoms with a 45-degree cut-off, are mounted in continuous rows flush against the 12-ft 9-inch ceiling. Lamps are 75-watt 96-inch standard cool white slimline. Resulting illumination is 58 footcandles on the main sales floor and approximately 40 ft-c in the office-sales floor section. The installation won a Merit Award for Marvin R. Hooge, Montana-Dakota Utilities Co., Miles City, Montana.

Are Often
Store Lighting

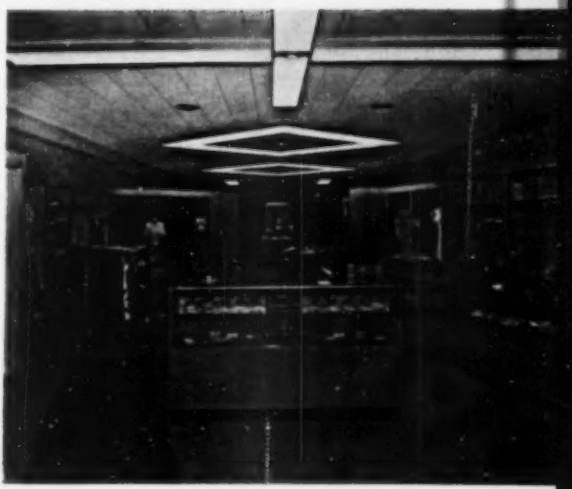
The art and science of attracting customers is not restricted to big city department stores. Nor is up-to-date lighting technique. All of the installations shown on this and the facing page won Merit Awards at the Fourth I.L.E. Contest; all are in relatively small towns.

→

Mt. Vernon, Ohio — The lighting problem in this sales area was to overcome the vast and impersonal atmosphere created by an extremely high ceiling (17 ft 6 inches) without the expense of architectural changes. Specifically, it was desired to create a false ceiling effect with the lighting system. The upper walls and ceiling were painted black orchid, to obliterate them visually, and luminaires (two-lamp 75-watt slimline, 430 ma) were arranged in squares with the centers enclosed with ceiling panel, mounted at a height 10 ft above the floor. The effect is of a ceiling of light; all hangers, conduit and sprinkler system are concealed by the psychological "receding" of the true ceiling. Supplemental lighting in the cases, clothes racks and on the shelves is provided by 40-watt fluorescent strips; 150-watt R40 reflector spots highlight feature displays. Brightness ratios are good since light colors are used throughout the area. Illumination levels range from 35 ft-c in the circulation area to 50-70 ft-c on counters, racks and shelves; with 85 ft-c on the feature display. The installation won a Merit Award for R. L. Dible, The Ohio Power Co., Mt. Vernon, Ohio.

→

Williston, North Dakota — Happip's ready to wear shop is a completely new building which has employed from the start, a pleasing selling environment of high level comfortable lighting. Slimline luminaires using 75-watt T12 lamps are used in combination with incandescent spot boxes. Light surfaces control brightness ratios. After 11 months' operation, levels of 100 to 120 ft-c were measured at counter top; hat tryout table was 60 to 70 ft-c. Average illumination is 40 to 50 ft-c over the merchandise and drops off to 20 ft-c in the traffic areas. The installation won a Merit Award or J. N. Vranish, Montana-Dakota Utilities Co., Bismarck, N. D.



An Experimental Appraisal Unit For Men's Clothing Stores

By KENNETH C. WELCH

The geometric distribution of light and color for the proper appraisal of fabric, color and fit of men's clothing, has been investigated in the experimental unit described.

BEHIND the development of the experimental unit described was the need to produce an appraisal light for men's clothing which would serve the functional needs of the lighting to do a better selling job. Daylight is poor at best in the canyons of our big cities and often fails when needed most—on the cloudy days of the best selling month of the year—December. Further, the color of light normally available in a men's store, for appraisal of fabric and color, whether by daylight or artificial light, is seldom entirely satisfactory from a selling point of view. The long-range interest of salesman, store owner and customer is—does a customer, when he buys a garment, know what he has purchased, especially from the color viewpoint? Will he be satisfied with it when he sees it in bright sunlight? An overcast day? Under typical home artificial light? When a man has purchased a blue-purple suit of 5 to 10 per cent reflectance, in a typical 20-footcandle incandescent light, he is often shocked at its color on a bright day. If he does not like it, he may find it difficult to return the merchandise under the circumstances, and so remains a partially dissatisfied customer.

The typical method of lighting triplicate mirrors, generally used for selling men's clothing, is to use overhead, mainly horizontal illumination. Even taking advantage of the mirror as a reflector, this method is not entirely satisfactory from a directional distribution standpoint as a selling light. In ready-to-wear clothing it exaggerates misfits, wrinkles and excessive portliness. The addition of vertical illumination, acting as a photographic "fill-in" light, however, minimizes this difficulty.

Design of the experimental appraisal unit shown includes an overhead cool-colored diffuse light, warm diffuse light at the sides of the mirror to provide vertical illumination, and an incandescent spot on a momentary on-switch. The latter is used only part of the time.

The overhead unit uses eight 42T6 cool white de luxe fluorescent lamps operating at 200 ma, with 40° to 45° shielding. The theory behind this structure was to produce a fairly large area of cool diffuse horizontal illumination. The unit is so angled that the outer edge is higher than the part adjacent to the panel and mirror. This gives a better distribution when the taller customer steps back farther away from the mirror.

The large mirror reflects these overhead lamps (see sketch) directly, helping to increase the cool illumination on the lower part of the figure, at almost a 45° angle on the upper part of the figure.

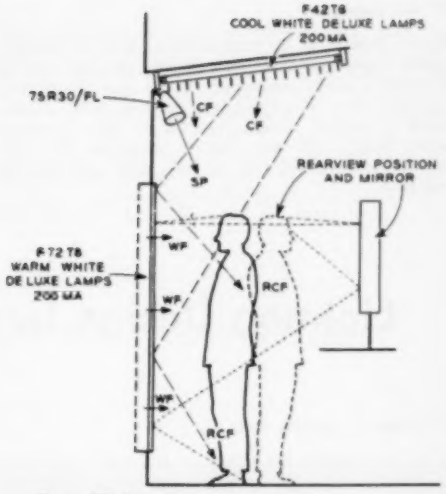
The illumination, being directional—*i.e.* from the direction of the large mirror toward the figure, the rear and side views are obtained by the customer turning and looking in the smaller mirror attached to the selling table. This ensures a rear view lighted as planned for the front, as illustrated. In other words, the illumination of the minor part of the figure, seen directly in a small mirror, is inadequate as it is of a much lower level and confined to only part of the overhead cool illumination plus the general illumination in the room.

The deluxe cool and warm tone fluorescent lamps are quite essential to the purpose of the unit. The rendition of flesh tones is very satisfactory and the variation in direction of the cool and warm illuminants gives a pleasing effect. When the spot is used, it produces psychologically, in a limited way perhaps, the effect on sunlight on a clear day, with its cool shadows and its comparatively warm highlights.

When the units are placed on opposite sides of a column, as they often are, it also produces an interesting design or aesthetic effect, tending to feature the selling function through light.

The average customer stands about 18 inches from the mirror (per sketch) when appraising the detail of fabric and color. He steps back to seldom more than 48 inches when appraising the overall effect of general appearance, fit and the like. (The small rear view mirror is shown to be 4 feet 6 inches from the large mirror in the sketch). In this latter position, the reflected image is seen within a vertical field of view subtending an angle of from 35° to 40°. As the customer moves farther away from

AUTHOR: Grand Rapids Store Equipment Co., Grand Rapids, Mich.



Rays of light — — — — — —
CF — Direct cool fluorescent
RCF — Cool fluorescent reflected from mirror
WF — Vertical warm fluorescent
SD — Direct spot incandescent

the mirror a greater amount of cool fluorescent light reaches the front of the garment, but note that the direct cool light as reflected from the mirror does not reach the face of the customer.

The incandescent spot is only useful when closer to the mirror and is mainly valuable in selling, to momentarily increase the level (necessary for low reflectance fabrics) and to give the effect of a greater amount of typical home illumination in appraising the color, and by producing a strongly unidirectional light which helps in the appraisal of certain fabric textures.

This experimental unit, tried out in a large clothing section of a department store, has proved to be quite successful as an appraisal-selling aid. Further, it has permitted a more efficient layout in that stock can be efficiently concentrated on the periphery of the floor, where daylight is usually available, and the selling and appraisal sections can be more conveniently distributed throughout the center of floor, which is not as conducive to efficient stock carrying.

The unit would be improved if the reflectance of the louvers were increased to produce twice the brightness, of the order say of 22 to 34 footlamberts. The improvement would not be due to the slight increase in level, but from a psychological standpoint in making the source of the overhead light a little more apparent. We are currently trying Munsell 8.3Y5.7/1.6 with about a 28 per cent reflectance, using a Plochere No. 188 as a sample.

The mirror side lighting in the model was by means of an indirect cove. It would be more easily maintained were it transmitted light through etched glass which could be an extension of the glass silvered for the mirror. It could also be a wider band with a slightly reduced brightness, of say a uniform 100 to 120 footlamberts but with the same total vertical amount of illumination.

It is possible to adopt this same principle to fitting rooms, with an improved distribution. The vertical illumination source can be increased in area and amount of illumination with a slightly lowered brightness.

I should like to acknowledge with thanks the cooperation of the General Electric Lamp Division, Nela Park, who supplied normally unavailable lamps for experimental use; the aid of Max Grove illuminating engineer of Chicago, who helped with the development of the lighting units; and Ray Balousek of Grossman Knowling Company of Detroit, who undertook the difficult assignment of making true-color slides.

← All Lights On

All the elements of the lighting system (left) in the new Lane's Department Store, in New York City, are applied to create a selling atmosphere. On the general appraisal lighting system as a foundation, has been built a variegated brightness pattern designed to place emphasis where desired and give interest throughout the area. Modern finishing materials and light colors contribute to the decor.

Lighting Design for

← General Lighting Only

A circular element was chosen for the design expression in this first floor area (left). The general lighting units are built to accommodate eight 15-watt T8 fluorescent lamps and a 300-watt incandescent lamp in a polished reflector in the center. The incandescents provide about 60 per cent of the total lumens. Although the general appraisal lighting of 30 footcandles is adequate, attraction for the merchandise is lacking, particularly at the perimeter of the store, with only this system turned on.

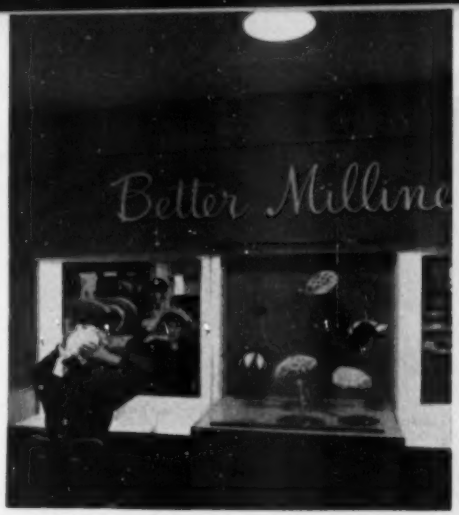
Wall Case Lighting Only →

The addition of light from two continuous rows of deluxe warm white fluorescent lamps, used in the wall cases (right) attracts attention to the perimeter displays. Light on the upper wall and ceiling gives a bright cheerful effect and an impression of spaciousness.

← Perimeter Spot Lights Only

Illumination at the perimeter of the room is boosted by the use of 150-watt R-40 floodlamps in recessed, louvered units. Where luminaires are uniformly spaced, the level at the walls is generally lower than in the center of the area. About 10 footcandles are supplied on counter tops from these downlights.

Complexion-flattering light, at 30-footcandle level, is supplied on the customer's face at the hat bar. A niche has been made in the wall and a mirror suspended from the top front edge giving a floating effect. Six 15-watt T8 de luxe warm white fluorescent lamps are concealed behind the mirror. Light reflected from the back and sides of the niche, which are finished in shell pink, is somewhat more pink in character than is the source. Fluorescent and incandescent sources provide the general illumination in the rest of the area.



Lane's, New York

Two separate but related systems provide 35 footcandles in this third floor area. Eight-foot troffer sections, each containing six 48T12 fluorescent lamps, are recessed in a regular pattern. Louvered downlights for 150-watt R-40 floodlights supply about 25 per cent of the total lumens. Wall displays are lighted by continuous rows of linear sources.

The infant specialty department is set apart from the general sales area by a change in ceiling height and lighting pattern. Louvered troffers, recessed in a non-continuous row over the showcases, are at right angles to those of the general area. The position of the units over the front edge of the showcases is to avoid reflections from the glass tops. Three rows of 48T12 warm white de luxe lamps provide 50 footcandles on the counter. The wall cases are lighted by a row of 40-watt T12 lamps concealed inside the sliding glass doors, with another row mounted in the open valance. Over the stock aisle recessed incandescent downlights with ribbed glass cover plates contain 200-watt lamps.

Architects: Cordes, Bartos and Mihnos, New York; Engineer: Bruce Jacobi, Chief Engineer, Lerner Stores Corp.

Mercury Vapor For Tunnel Lighting

By CLEMENT A. FELZER

MERCURY VAPOR lamps not only can be used successfully for tunnel lighting but, where the section is circular, can be installed economically. If traffic is uni-directional, this system becomes most advantageous.

A mercury vapor installation was made early in 1951 in the Lake Way Tunnels entering Seattle on U.S. 10 with highly successful results. The Lake Way Tunnels consist of twin bores 1466 feet long, each with two lanes of one-way traffic. The tunnels were built in 1940, at which time a system of sodium vapor lighting was installed, the lights being supported close to the ceiling at 60-foot center. The average illumination on the roadway by this system was 0.3 footcandle.

The recent relighting was part of Seattle's vast street lighting program. Top-mounted, horizontal-burning luminaires with EH-1 mercury vapor lamps are suspended from the tunnel ceiling on four-inch channels, at a mounting height of 20 feet. The channels also carry the ballasts for each luminaire, and the cable racks for supporting the feeder cables, providing power on a multiple-circuit system.

Each luminaire is provided with a special aluminum shield attached to the side facing on-coming traffic, as shown in the photograph. It was determined by experimentation that the shield should cover all the glassware, eliminating direct glare. The comfort afforded by such shielding is an important factor in the success of the installation. The average illumination on the roadway is now 4.3 footcandles. This is obtained by single units on 40-foot centers.

In order to permit the eye to become adjusted from the high intensity of daylight outside to the relative darkness of the tunnel, the mercury luminaires were installed as double units (see photo) with spacing varying from eight feet to 40 feet. The illumination, 60 feet inside the tunnel, where daylight penetration is negligible, is 47 footcandles. Closer to the entrance, the combined daylight and artificial light reaches higher levels, depending on whether it is a bright or cloudy day. The entrance lighting tapers off in a distance of 250 feet to the 4.3 footcandle level in the tunnel.

Photo-electric cells control the entrance or daytime lighting, and turn it on in the morning when daylight reaches 500 footcandles. These cells turn the light off in the evening when the daylight levels fall below 400 footcandles. Approaching the tunnel under bright sunlight conditions, the entrance looks like a dark hole from a distance, but as you get closer, the light on the roadway becomes apparent and after passing the portal, all details become clearly visible. There is no place in the transition from outside to inside where objects on the tunnel roadway are not clearly visible.

The sidewalls at each entrance were painted white for a distance of 300 feet as an additional aid to the entrance lighting. No lining was provided in the original construction of the tunnel, beyond a smooth concrete finish. It was originally intended to paint the complete length of each tunnel, but illumination of the sidewalls and ceiling, and the light intensity on the roadway have proved this unnecessary.

The Seattle Engineering Department points out that mercury vapor lighting cannot take the place of fluorescent lighting for tunnels in all cases, but where a mounting height of 20 feet can be obtained, an economical and efficient job can be done with this system.

AUTHOR: Department of Engineering, City of Seattle. This installation won a Merit Award at the Fourth International Lighting Exposition, as Entry No. 537.

INSTALLATION AT WOLF'S CHARMLEY DRUG STORE, 164 HALSEY STREET, NEWARK, NEW JERSEY

Lighting a Drug Store

LIGHTING OBJECTIVE: To provide a uniform high level of illumination attractively in a small drug store.

GENERAL INFORMATION: This drug store is approximately 50 feet long and 14 feet wide. The upper walls are light green (54% RF), paneling in upper left foreground is brown (9% RF), showcases have a blond mahogany finish (60% RF) and the floor is light green terrazza (39% RF).

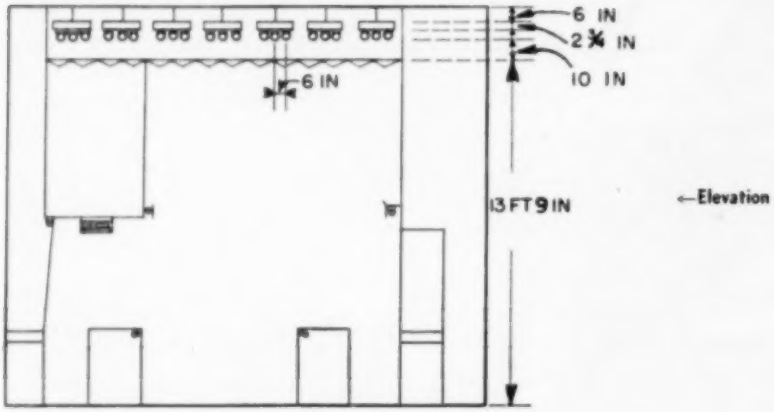
INSTALLATION: The luminous ceiling is composed of 24-inch square shallow plastic basins formed from .080-inch white translucent Plexiglas supplied by the Steiner Plastics Manufacturing Co., Inc., Glen Cove, Long Island. The plastic is supported 13 feet 9 inches above the floor by T-bar iron strips located across the width of the store and supported by rods from the ceiling. The divisions between the squares lengthwise of the store consist of plastic strips of a darker color fastened to one edge of the square panels.

Ten inches above the plastic over thecenter of each plastic panel (24 inches apart) are installed continuous lengthwise rows of standard cool white fluorescent lamps in Ruby-Philite No. 8003-Special luminaires. These units are 16 inches wide and 2¾ inches deep; each contains three lamps spaced 6 inches apart.

Additional illumination is provided under the curtain wall at the back by a row of eight surface-mounted Neo-Ray No. 728248 louvered units each containing two 40-watt standard cool white lamps. A single row of 8 40-watt and 2 20-watt Ruby-Philite No. 8001 channel units is installed behind a valance above the wall shelves. The display cases contain standard warm white lamps.

(over)

A.I.A. File No. 31



An average level of 140 footcandles is maintained in the center of the store, with 135 footcandles on the counter under the supplementary units at the rear. Brightnesses are listed below:

ceiling	330—422 ft·L
brown paneling at left	
specular reflection of ceiling	45 ft·L
near right-angle intersection with green wallpaper	17.5 ft·L
wall	
curved portion at left	85 ft·L
rear	50 ft·L
right	70 ft·L
floor	
foreground	48 ft·L
rear	28 ft·L
sides of display cases	18 ft·L

Architects: Kelly and Gruzen, New York City; lighting installed by Broad Electric Co., Newark.

Lighting data submitted by Walter S. Greenwood, Public Service Electric and Gas Company, Newark, N. J., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

A Survey of U.S. and Canadian Colleges Offering Illumination Courses

Report of the I.E.S. Committee on Lighting Education*

SIXTEEN years ago a survey of lighting education in the United States was conducted by the I.E.S. Committee on Lighting Education as a part of a "world-wide" survey to be reported to the International Commission on Illumination. The United States survey was reported by the Committee Chairman, Professor C. D. Fawcett, University of Pennsylvania (*I.E.S. Transactions*, September 1935, p. 621-636). This was the first survey of this nature made by the I.E.S., and it was suggested that "future surveys, if made, would indicate general tendencies in thought which may influence the scope of educational curricula of the future."

Since the 1935 survey, many extraordinary advancements have been made in the field of light source development and in illumination practice which would presume to have resulted in greater emphasis on the training of students in technical colleges in courses in or allied with illuminating engineering. It seems appropriate that this latest survey should have been conducted, as a supplement to Professor Fawcett's work, to determine whether our engineering schools have kept pace with this growing demand for professional men in this fast changing field.

One of the 1951 assignments to the I.E.S. Educational Committee was to conduct a survey reporting on illumination courses given by United States and Canadian engineering schools, undergraduate and graduate, and to find out which, if any, colleges grant degrees in illuminating engineering. A survey form was sent in March, 1951, to each of 150 colleges and universities* in the United States and

*Approved by the I.E.S. Council, June 1952.

*U. S. Schools, of Engineering, Technology and Applied Science from the 1950 edition of Patterson's *American Educational Directory*. Canadian schools taken from "Universities of the World Outside of the U.S.A."

TABLE I.—Compilation of College Survey Results — 1951
136 Colleges Reporting — U. S. 119; Canadian 17.

Figures in parentheses are equivalent percentages from 1935 survey of 126 reporting colleges.

	I PHYSICS		II ILLUMINATION		III ADVANCED LIGHTING			IV OTHER SPECIALIZED		
Number of schools reporting at least one required course	52	38.2%	38	27.9% (47.6%)	3	2.2%	(35%)	2	1.5%	(15%)
Number of schools reporting at least one elective and none required	6	4.7%	30	36.8% (30.0%)	16	11.8%		6	5.9%	
Total number of required courses	55		44		5			4		
Year Given: Freshman	6		0		0			0		
Sophomore	44		3		0			0		
Junior	4		14		1			0		
Senior	1		23		4			4		
Graduate or 5th year	—		4		—			0		
Total number of elective courses	24		54		20			13		
Year Given: Freshman	1		0		0			0		
Sophomore	1		1		0			0		
Junior	10		16		0			0		
Senior	8		35		13			4		
Graduate or 5th year	4		2		7			9		

NOTES: I. *Physics* — Basic courses in illumination probably offered in freshman or sophomore work and taught as separate course in physics or as part of basic physics course.

II. *Illumination* — Basic courses in illumination dealing with derivation of fundamentals of illuminating engineering, and with basic design methods used in commercial and industrial lighting layouts. Probably offered in sophomore or junior year.

III. *Advanced Illumination* — Courses offered in junior or senior years concerning optics, photometry, illumination measurements and instruments, calculation of illumination from line or extended surface sources, technical aspects of illumination sources, advanced layout design, etc.

IV. *Other Specialized* — Special problem courses offered as senior or graduate work in which the student is introduced to the research field, with formal reports required. Or, this type of course may concern graduate work in the fields of optics, sources or illumination design.

39 in Canada.† Replies were received from 136 of this list, 119 U.S. and 17 Canadian. This seems quite satisfactory in view of the fact that many of the schools, especially Canadian, probably do not offer engineering curricula. A compilation of the results of these 136 answers is presented in this article. The 1935 survey was sent to 133 colleges from which 126 replies were received.

†Not included in any of the summarized statistics, but appearing in Table IV are data received from two optometric schools which give lighting courses.

TABLE II.—General Questions.

1. Do you feel that courses in illumination in a four-year curriculum should be:

		1951	1935
(a) required	29	21.0%	23.0%
(b) offered as electives	72	53.0%	26.0%
(c) not offered	7	5.0%	10.0%
(d) not answering	28	21.0%	31.0%
		100.0%	90.0%

2. In a five year curriculum

		1951	1935
(a) required	54	40.0%	50.0%
(b) offered as electives	56	41.0%	20.0%
(c) not offered	2	1.5%	3.0%
(d) not answering	24	17.5%	27.0%
		100.0%	100.0%

3. Is there a Department of Architecture in your institution?

		1951	1935
(a) yes	58	42.5%	40.0%
(b) no	61	45.0%	
(c) not answering	17	12.5%	
		100.0%	

4. Is a degree in Illuminating Engineering granted by your institution?

		1951
(a) yes	0	
(b) no	120	90%
(c) not answering	13	10%

5. Is the field of illumination considered a major option in electrical engineering at your institution?

		1951
(a) yes	4	3%
(b) no	123	90%
(c) not answering	10	7%

6. Do you feel that there is sufficient interest in the field of illumination to consider forming a student branch of I.E.S. at your institution?

		1951
(a) yes	8	6%
(b) no	101	74%
(c) perhaps	8	6%
(d) not answering	19	14%

7. Approx. total number of students taking illumination work as a minor option *748*, as a major option *38*.
8. Approx. total undergrad. students *2692* and grad. students *69* taking some illumination work.
9. Illumination courses open to non-E.E. students: 75 affirmative replies out of 136 returned questionnaires. Illumination courses open to non-engineering students: 40 affirmative replies out of 136 returned questionnaires.

Summary of Survey Results

The status of courses, required and elective, is summarized in Table I. The colleges reporting are given in Table IV. Where quantitative comparisons with the 1935 survey could be made, these are shown by the per cent figures—the 1935 figures in parentheses. How much weight should be given to Physics I courses is open to conjecture. General physics courses which include light are almost inevitable prerequisites for engineering courses. In the 1935 survey 98 per cent indicated a study of light in such courses. Our questionnaire intended reports only on such courses where light or illumination were specifically named in credit hours given in physics courses.

A number of general questions were asked and these are summarized in Table II.

Textbooks Used

Of quite some general interest, it seemed to us, would be the textbook material used in illumination classes. The survey results are tabulated in Table III. About half of the textbooks named seemed to apply to physics courses rather than to the specialized study of illuminating engineering.

TABLE III.—Textbooks Used—Title and Author.

	No. of Courses	Per Cent
Manufacturers' Data	52	23
Electric Illumination, Kraehenbuehl	43	19
I.E.S. Handbook	22	10
Principles of Physics, Sears	14	6
Illumination Engineering, Boast	13	6
I.E.S. Transactions	17	8
Scientific Basis of Illuminating Engineering, Moon	20	9
Physics, Hausmann & Slack	8	4
Fundamentals of Optics, Jenkins & White	6	3
Photometry & Illumination, Barrows	5	2
Illuminating Engineering, Schilling	5	2
University Physics, Sears & Zemansky	4	2
Lighting Design, Moon & Spencer	3	1
Fluorescent Lighting Manual, Amick	3	1
Fluorescent and Other Gaseous Discharge Lamps, Forsythe & Adams	2	1
Measurement of Radiant Energy, Forsythe	2	1
Introduction to Physical Optics, Robertson	1	1
Analytical Experimental Physics	1	1
Introduction to Lighting, Sharp	2	1

Other textbooks mentioned as principle or supplementary course material are:

Text of Illuminating Engineering, Walsh
Photometry, Walsh
Electric Discharge Lamps, Cotton
Photographic Principles, Mach & Martin
Electric Plant of Buildings, Gay & Fawcett
College Physics; Mendenhall, Keys, Sutton
Elementary Physics, Black
Science of Seeing, Luckiesh & Moss
Elementary Medical Physics, Stearns

TABLE IV.—United States Schools of Engineering, Technology and Applied Science

State	City	Institution	Types of Courses Offered†			
Alabama	Auburn	Alabama Polytechnic Institute	I	II		
Alabama	University	University of Alabama		II		
Arizona	Tucson	University of Arizona				
Arkansas	Fayetteville	University of Arkansas		II		
California	Pasadena	California Institute of Technology				
California	Los Angeles	Los Angeles College of Optometry*		II		
California	Berkeley	University of California		II	III	IV
California	Los Angeles	University of California			III	
California	Santa Clara	University of Santa Clara		II		
California	Los Angeles	University of Southern California	I	II		
Colorado	Fort Collins	Colorado A. & M. College		II		
Colorado	Boulder	University of Colorado		II		
Colorado	Denver	University of Denver		II		
Connecticut	New London	United States Coast Guard Academy				
Connecticut	Storrs	University of Connecticut	I	II	III	IV
Connecticut	New Haven	Yale University				
Delaware	Newark	University of Delaware				
Dist. of Columbia	Washington	Catholic University of America				
Florida	Gainesville	University of Florida	I	II		
Florida	Coral Gables	University of Miami		II		
Georgia	Atlanta	Georgia Institute of Technology		II		
Georgia	Chamblee	Georgia Institute of Technology's Southern Technical Institute	I	II		
Idaho	Moscow	University of Idaho	I	II		
Illinois	Peoria	Bradley University	I	II		
Illinois	Chicago	Illinois Institute of Technology				
Illinois	Chicago	University of Illinois (Navy Pier Branch)	I	II		
Illinois	Evanston	Northwestern University	I	II		
Illinois	S. St. Louis	St. Louis University				
Illinois	Urbana	University of Illinois	I	II	III	IV
Indiana	Fort Wayne	Indiana Technical College	I			
Indiana	Lafayette	Purdue University	I	II		
Indiana	Terre Haute	Rose Polytechnic Institute	I	II		
Indiana	Angola	Tri-State College of Engineering	I			
Indiana	Notre Dame	University of Notre Dame		II		
Iowa	Ames	Iowa State College		II	III	IV
Kansas	Manhattan	Kansas State College		II		
Kansas	Lawrence	University of Kansas		II		
Kentucky	Lexington	University of Kentucky			III	
Kentucky	Louisville	University of Louisville	I	II		
Louisiana	New Orleans	Tulane University		II		
Maine	Orono	University of Maine		II		
Maryland	Baltimore	Johns Hopkins University		II		
Maryland	College Park	University of Maryland	I			
Massachusetts	Cambridge	Massachusetts Institute of Technology		II		
Massachusetts	Boston	Northeastern University				
Massachusetts	Worcester	Worcester Polytechnic Institute		II		
Michigan	Detroit	Detroit Institute of Technology		II		
Michigan	Detroit	Lawrence Institute of Technology	I	II		
Michigan	East Lansing	Michigan State College		II		
Michigan	Detroit	University of Detroit		II		
Michigan	Ann Arbor	University of Michigan		II	III	IV
Michigan	Detroit	Wayne University		II		
Minnesota	Minneapolis	University of Minnesota	I	II		
Mississippi	State College	Mississippi State College	I	II	III	
Mississippi	University	University of Mississippi	I	II		
Missouri	Columbia	University of Missouri		II		IV
Missouri	St. Louis	Washington University	I	II		
Montana	Bozeman	Montana State College	I	II		

*Optometry school, data not included in statistical analyses.
†I—Basic Physics; II—Illumination; III—Advanced Lighting; IV—Other Specialized.

State	City	Institution	Types of Courses Offered†			
Nebraska	Lincoln	University of Nebraska		II		
New Hampshire	Hanover	Dartmouth College	I			
New Hampshire	Durham	University of New Hampshire	I	II		
New Jersey	Newark	Newark College of Engineering	I			
New Jersey	Princeton	Princeton University	I			
New Jersey	New Brunswick	Rutgers University				
New Jersey	Hoboken	Stevens Institute of Technology		II		
New Mexico	State College	New Mexico College of Agriculture and Mechanical Arts	I			
New York	New York	City College	I	II		
New York	Potsdam	Clarkson College of Technology		II		
New York	New York	Columbia University				
New York	New York	Cooper Union		II		
New York	Ithaca	Cornell University		II	III	IV
New York	New York	New York University	I			
New York	Brooklyn	Polytechnic Institute of Brooklyn		II		
New York	Brooklyn	Pratt Institute	I			
New York	Troy	Rensselaer Polytechnic Institute	I	II		
New York	Rochester	Rochester Institute of Technology	I	II		
New York	Syracuse	Syracuse University				
New York	Buffalo	University of Buffalo		II	III	
No. Carolina	Durham	Duke University College of Engineering	I	II		
No. Dakota	Fargo	North Dakota State College	I	II		
Ohio	Cleveland	Case Institute of Technology	I	II	III	IV
Ohio	Columbus	Ohio State University				
Ohio	Athens	Ohio University		II		
Ohio	Akron	University of Akron	I	II		
Ohio	Cincinnati	University of Cincinnati	I	II		
Ohio	Toledo	University of Toledo		II		
Oklahoma	Stillwater	Oklahoma A. & M. College	I	II		
Oklahoma	Goodwell	Pan-Handle Agricultural and Mechanical College	I	II		
Oklahoma	Norman	University of Oklahoma				
Oklahoma	Tulsa	University of Tulsa	I			
Oregon	Portland	Oregon Institute of Technology				
Oregon	Corvallis	Oregon State College	I	II		
Oregon	Forest Grove	Pacific College of Optometry*	I	II		
Pennsylvania	Pittsburgh	Carnegie Institute of Technology	I			
Pennsylvania	Philadelphia	Drexel Institute of Technology	I			
Pennsylvania	Bethlehem	Lehigh University	I			IV
Pennsylvania	State College	Pennsylvania State College		II	III	
Pennsylvania	Philadelphia	University of Pennsylvania	I	II		
Pennsylvania	Pittsburgh	University of Pittsburgh	I			
Pennsylvania	Villanova	Villanova College		II		
So. Carolina	Columbia	University of South Carolina	I	II		
So. Dakota	Brookings	South Dakota State College	I			
Tennessee	Cookeville	Tennessee Polytechnic Institute				
Tennessee	Knoxville	University of Tennessee				
Tennessee	Nashville	Vanderbilt University				
Texas	College Station	Agricultural and Mechanical College of Texas		II	III	
Texas	Stephenville	Tarleton State College				
Texas	Houston	Rice Institute			III	
Texas	Dallas	Southern Methodist University		II	III	
Texas	Austin	University of Texas		II	III	
Utah	Salt Lake City	University of Utah		II		
Utah	Logan	Utah State Agricultural College	I			
Virginia	Charlottesville	University of Virginia		II		
Virginia	Blacksburg	Virginia Polytechnic Institute		II	III	
Washington	Pullman	State College of Washington				
Washington	Seattle	University of Washington	I	II		
W. Virginia	Morgantown	West Virginia University	I	II		
Wisconsin	Milwaukee	Milwaukee School of Engineering		II		
Wisconsin	Madison	University of Wisconsin		II		

*Optometry school, data not included in statistical analyses.
†I—Basic Physics; II—Illumination; III—Advanced Lighting; IV—Other Specialized.

Canadian Universities

Province	City	Institution	Types of Courses Offered?
Nova Scotia	Halifax	Dalhousie University	I
Quebec	Montreal	Loyola College	
Quebec	Montreal	McGill University	II
Ontario	Hamilton	McMaster University	
New Brunswick	Sackville	Mount Allison University	I
Nova Scotia	Halifax	Nova Scotia Technical College	II
Ontario	Guelph	Ontario Agricultural College	
Ontario	Toronto	Ontario College of Pharmacy	I
Ontario	Kingston	Queen's University	
Quebec	Montreal	Sir George Williams College	
Quebec	Quebec	Laval University	
Alberta	Edmonton	University of Alberta	II
British Columbia	Vancouver	University of British Columbia	II
Manitoba	Winnipeg	University of Manitoba	II
New Brunswick	Fredericton	University of New Brunswick	I II
Saskatchewan	Saskatoon	University of Saskatchewan	I II
Ontario	Toronto	University of Toronto	II III

I—Basic Physics; II—Illumination; III—Advanced Lighting; IV—Other Specialized.

Survey Conclusions

The status of illuminating engineering in the programming of engineering college curricula has long been a matter of concern to those closely associated with such matters. A study of the compilation of survey data in Table I indicates there is reason for concern in this respect. This is evidenced in the following conclusions easily obtainable from the above compilation of data:

1. The number of courses dealing with illumination, both required and elective, is less today than in 1935.
2. Less emphasis is being placed on these courses today than in 1935, shown by the fact that the percentage of required courses has decreased while the percentage of elective courses has increased.
3. A smaller percentage of men in the engineering educational field, as a whole, feel that courses in illumination should be required in a four-year curriculum (now—21 per cent, 1935—23 per cent) and in a five-year curriculum (now—40 per cent, 1935—50 per cent).

Related Comment

The growing trend to built-in lighting, or "architectural lighting" as it is sometimes called—troffers, luminous ceilings, downlighting, soffit lighting elements, and the like, would seem to support the need for courses for architects and be almost an essential requirement. Of the 58 colleges having a department of architecture, just 16 required courses for architects only are offered, with five elective courses offered.

College professors concerned have very logical explanations for this seeming regression in interest of colleges in specialized training in illumination for electrical students. Mostly these boil down to the market demand for their product, the graduate. It appears that not many job opportunities are definitely predicated on lighting specialization in college. Appended to this report, as submitted to Council, was the pertinent comment submitted before the survey was made, by B. S. Timoshenko, Professor and Head of Department of Electrical Engineering, University of Connecticut, Storrs, Conn. (See June 1952 ILLUMINATING ENGINEERING, page 295.)

Report prepared by

Wendell E. Miller, Assistant Dean, College of Engineering, and Assoc. Professor, Department of Electrical Engineering, University of Illinois

Robert S. Wiseman, Assistant Professor of Electrical Engineering on leave from Mississippi State College; now a graduate student for Ph.D. degree at University of Illinois

Committee Members:

C. E. Weitz, General Electric Co., Chairman
B. S. Benson, Benjamin Electric Manufacturing Co.
W. B. Boast, Iowa State College
S. K. Guth, Nela Park, General Electric Co.
O. D. Hunt, Kansas State College
W. B. Kennedy, Sylvania Electric Products Inc.
E. K. Kraybill, Duke University
Carter Lewis, Union Electric Co.
Robert Ligare, Chicago Lighting Institute
Ralph R. Lusk, Chicago Lighting Institute
C. D. Miller, Duquesne Light Co.
W. E. Miller, University of Illinois
J. F. Parsons, Niagara Mohawk Power Corp.
H. A. Stroud, Monongahela W. Penn. Pub. Serv. Co.
D. C. White, University of Florida
E. L. Dodington, University of Toronto
R. S. Wiseman, University of Illinois

Light Depreciation Survey

Tests of the light depreciation of twenty different typical fluorescent luminaires in a Roanoke office building

By V. L. DZWONCZYK

WHILE it is becoming recognized generally that many benefits accrue from a good lighting installation, which justify the initial cost, there appears to be some lack of appreciation of how much of the initial investment is wasted by the depreciation of a lighting installation. Any or all of the following losses may occur:

1. Loss due to lamp aging.
2. Loss due to low voltage.
3. Loss due to luminaire inefficiency.
4. Loss due to condition of room surfaces.
5. Loss due to dirt, dust and smoke.
6. Loss due to lamp outages.

The purpose of this paper is to record some interesting data regarding the depreciation of light output from typical commercial fluorescent luminaires which have been installed in a totally air-conditioned space. Included in this study are suspended, surface-mounted and troffer units which are equipped with solid glass or plastic bottoms and with louvers. The study is made under controlled conditions, but under normal working situations of a typical public utility general office building.

The test areas are located in the general office of the Appalachian Electric Power Co., one of the operating companies of the American Gas and Electric Co. system. Approximately 400 people comprising the general staff have occupied the building located at 40 Franklin Road, Roanoke, Virginia, since April 1949.

The office is 100 feet wide by 152 feet long and is six stories tall with design provisions of three additional floors. The entire building is completely air-conditioned by an electric heat pump and is illuminated with fluorescent luminaires, most of which are suspended but some of which are recessed troffers and surface-mounted types.

This lighting system was designed with the philosophy that:

(a) The lighting level should be adequate for the visual tasks performed in each area consistent with good economic criteria.

(b) An assortment of several types of luminaires and systems should be used to serve as tools for the lighting sales representatives when they discuss equipment and systems with their customers.

(c) Reasonably similar luminaire layouts in several selected rooms should be made so that a depreciation survey could be made on selected typical types of fluorescent luminaires.

The results of the latter objective represent the subject of this paper.

Lighting levels throughout the building meet good office lighting practice. Two months after the building was occupied the 20 test rooms averaged between 35 and 73 footcandles, respectively, directly after the luminaires were cleaned but with the original lamps in service.

Fluorescent luminaires used in this building and selected for this survey are tabulated in Table I, together with some of their pertinent characteristics. These fixtures, at the time of installation, represented available units having relatively low brightness, high coefficient of utilization, structural sturdiness and reasonably good esthetic appearance. Some of these units have proved to be unsound in their structural makeup, others would no longer be chosen for reasons of high depreciation and because more recently designed equipment offers features that are substantially better.

Method of Test

The twenty luminaires selected for this survey and described in Table I were installed in rooms having reasonably similar features. In order to reduce the labor involved in performing the tests, it was decided to base the results on an average of a limited number of specific test points so selected that the light directed to these points represented not only the direct rays but also those which had to reach the test points by one or several reflections. It is recognized that a more accurate procedure would be to utilize methods proposed for general illumination surveys by the Illuminating Engineering Society, but it is questionable whether the final conclusions would be appreciably affected by that method of obtaining such data.

Fig. 1 shows a typical example of how these test points were selected. In the larger rooms as many as nine test points were used to obtain the average but no less than four points were used even in the smallest room.

Before the survey was undertaken the twin-cell

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TABLE I.—Light Depreciation Survey — Roanoke Office — Appalachian Electric Power Company. Fluorescent Fixture Data — 1948 Designs.

Test Areas		Fluorescent Fixture Data							
			Classification	Lamps per Fixture		% Light Output			
No.	Office Use	Manufacturer	No.	No.	Watts	0-90°	90-180°	Efficiency	General Description
1	Power Sales Supervisor	A	YE-4	4	40	38.4	47.0	85.4	Suspended, Louver Bottom, Glass Sides
2	Power Sales	B	110-ASL	2	40	33.8	45.8	79.6	Ditto
3	Lobby	C	——	2	40	46	0	46	Troffer, Opal Glass enamel reflector
4	Corridor	D	CL-40	1	40	50.8	14.4	65.2	Surface Mounted, Glass Globe
5	Telephone Room	E	ST-248	2	40	7.5	63.5	71	Suspended, Plastic Bowl
6	Cashier's Work Space	F	4-N-200L	4	40	40.5	34.0	74.5	Suspended, Louver Bottom, Glass Sides
7	Safety Department	E	GRL-248	2	40	38.7	39.2	77.9	Suspended, Louver (wide) Bottom, Plastic Sides
8	Residential Supervisor	B	110-ASG	4	40	39.6	45.9	85.5	Suspended, Glass Bottom, Glass Sides
9	Residential Light Engineer	F	4-N-200G	4	40	39.5	33.0	72.5	Suspended, Glass Bottom, Glass Sides
10	Mail Room	A	D-21	2	40	44.3	15.0	59.3	Suspended, Louver Bottom
11	Secretaries	G	46203	2	40	44.0	30.5	74.5	Ditto
12	Stenographers	H	4060	2	40	47.0	32.1	79.1	Suspended, Louver (wide) Bottom, Metal Sides
13	Office	E	GRL-448	4	40	34.5	43.0	77.5	Suspended, Louver (wide) Bottom, Plastic Sides
14	Office	D	1371609	4	40	34.0	44.5	78.5	Suspended, Louver Bottom, Glass Sides
15	Office	B	110-ASL	2	40	33.8	45.8	79.6	Ditto
16	Meeting Room	G	42275	2	40	50	0	50	Troffer, Louver (wide) Bottom, Alum. Reflector
17	Administrative	H	51	4	40	32.3	46.0	78.3	Suspended, Louver Bottom
18	General Manager	I	9101-2	2 & 3	40	68.8	0	68.8	Troffer, Prismatic Lens Bottom, Enam. Reflector
19	Asst. General Manager	J	12448L	4	40	25.0	46.0	71.0	Suspended, Louver Bottom
20	Office	D	1219988	4	40	33.0	45.5	78.5	Suspended, Glass Bottom, Glass Sides

model 603, Weston Illumination Meter was calibrated by the manufacturer and a reference calibration curve was made to insure that the meter would not undergo a serious change in calibration during the several months that would have to elapse for this survey to be completed. To obtain this reference curve a black box was constructed in which the photocell could be placed beneath a suitable incandescent lamp at a fixed distance. Before each survey was made a voltage *vs* illumination curve was obtained for purposes of comparison with the initial calibration. If changes in calibration were detected, these curves were used to correct the observed illumination readings in each of the successive surveys. The surveys were conducted approximately 3, 8, and 14½ months after the initial tests and cleaning of fixtures. The lamps were not cleaned nor changed during the survey period and they each operated about 210 hours per month.

During each survey the voltage in the rooms in which the tests were made was also recorded and any change from the original was used to correct the illumination readings so that all data were referred to the same base.

Results

The results of this survey are analyzed in Table II and summarized in Table III. Fig. 2 illustrates graphically the progressive depreciation of illumination in each of the 20 test rooms.

While the results do not illustrate anything radically different from what might be expected, some of the specific and relative values of depreciation seem to be significant. For instance, it is noted that a considerable difference in depreciation rate appears for similar classes of luminaires made by different manufacturers. By classes it is meant whether they are suspended, surface-mounted or of the troffer variety. The fact that there are rather wide rates of depreciation in each of the classes would signify that the structural arrangement of parts of the various fixtures appreciably affects the rate at which dirt, dust and grime accumulate on them. It would seem that these shapes and arrangements of parts should be given considerable atten-

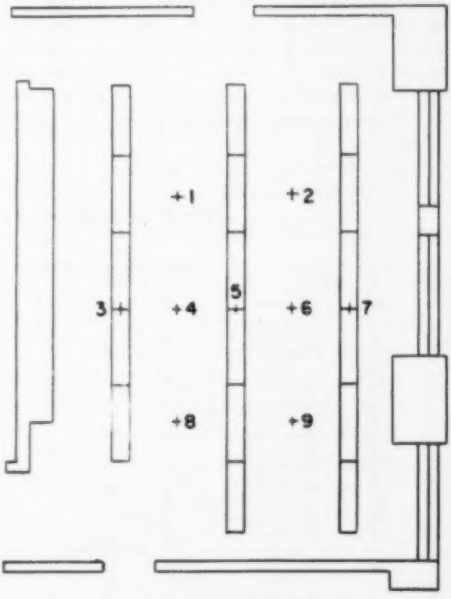

Figure 1. Typical light depreciation survey test points.

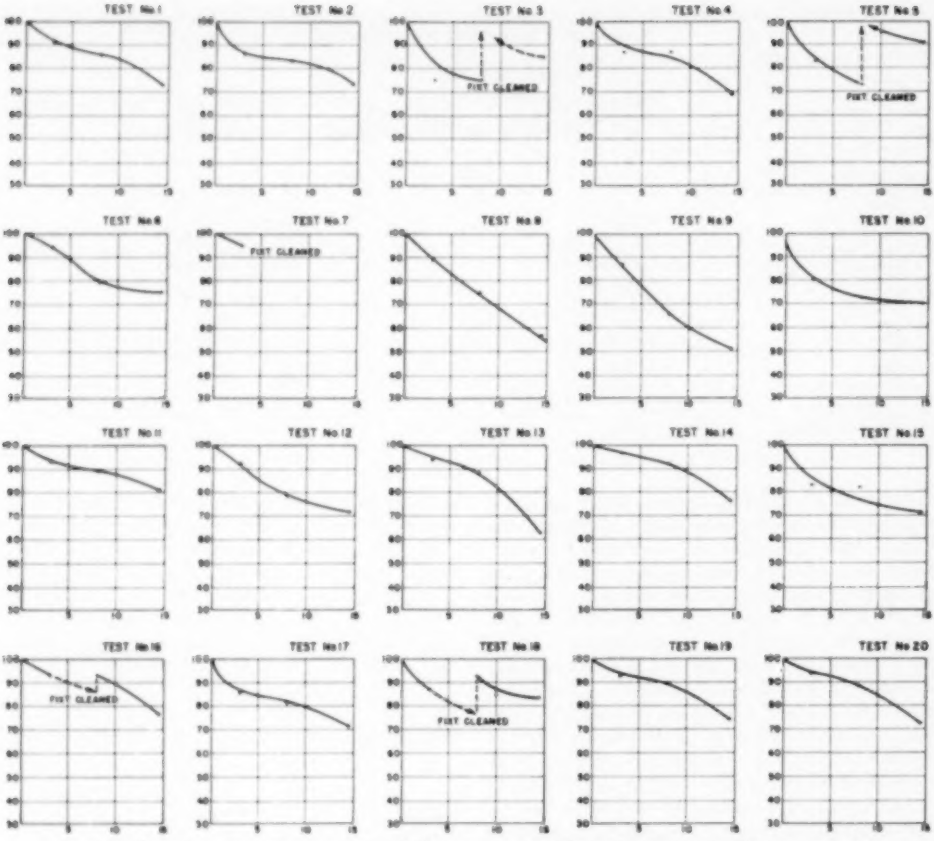

Figure 2. Light depreciation survey data. Ordinates—average illumination per cent. Abscissa—months.

TABLE II.—Analysis of Illumination Depreciation Data.

Test No.	Fixture Mfr.	Fixture Mounting	Total % Light Output Depreciation Months 3	Total % Light Output Depreciation Months 8	Total % Light Output Depreciation Months 14.5	Average % Depreciation per Month Months 3	Average % Depreciation per Month Months 8	Average % Depreciation per Month Months 14.5	Relative Order Based on Depreciation Months 3	Relative Order Based on Depreciation Months 8	Relative Order Based on Depreciation Months 14.5
1	A	Suspended	9	14	27	3.0	1.8	1.9	10	6.5	7.5
2	B	Suspended	14	17	27	4.7	2.1	1.9	16	9	7.5
3	C	Troffer	18	25		6.0	3.1		19	13.5	
4	D	Surface	11	15	31	3.7	1.9	2.1	11.5	8	12
5	E	Suspended	16	27		5.3	3.4		18	17.5	
6	F	Suspended	6	21	25	2.0	2.6	1.7	5.5	11.5	3.5
7	E	Suspended	5			1.7			4.5		
8	B	Suspended	11	25	43	3.7	3.1	2.0	11.5	15.5	14
9	F	Suspended	13	34	49	4.3	4.3	3.4	13.5	19	15
10	A	Suspended	19	27	29	6.3	3.4	2.0	20	17.5	11
11	G	Suspended	7	11	19	2.3	1.4	1.3	8.0	4	1
12	H	Suspended	6	21	28	1.7	2.6	1.9	4.5	11.5	7.5
13	E	Suspended	5	11	37	1.7	1.4	2.6	4.5	4	13
14	D	Suspended	3	8	23	1.0	1.0	1.6	1	1	2
15	H	Suspended	14	23	28	4.7	2.9	1.9	16	13.5	7.5
16	G	Troffer	7	14		2.3	1.8		8.0	6.5	
17	H	Suspended	14	18	26	4.7	2.3	1.9	16	10	7.5
18	I	Troffer	13	23		4.3	2.9		13.5	13.5	
19	J	Suspended	7	10	25	2.3	1.3	1.7	8.0	2	3.5
20	D	Suspended	6	11	27	2.0	1.4	1.9	5.5	4	7.5

TABLE III.—Summary.
Average Per Cent Depreciation per Month of Light Output.
(Arranged on order of increasing depreciation.)

Suspended Fixture — Louvered Bottom

Months of Operation: 3		8		14.5	
Test No.	Deprec. %	Test No.	Deprec. %	Test No.	Deprec. %
14	1.0	14	1.0	11	1.3
12		19	1.3	14	1.6
13	1.7	13	1.4	19	1.7
7		11		6	
6	2.0	1	1.8	17	
19		2	2.1	15	
11	2.3	17	2.3	12	1.9
1	3.0	12	2.6	1	
17		6		2	
15	4.7	15	2.9	10	2.0
2		10	3.4	13	2.6
10	6.3				
Aver.	3	Aver.	1.2	Aver.	1.9

Suspended Fixture — Glass Bottom

20	2.0	20	1.4	20	1.9
8	3.7	8	3.1	8	2.6
9	4.3	5	3.4	9	2.4
5	5.3	9	4.3		
Aver.	3.8	Aver.	3.1	Aver.	2.3

Troffers — Louvered

Months of Operation: 3		8		14.5	
Test No.	Deprec. %	Test No.	Deprec. %	Test No.	Deprec. %
16	2.3	16	1.6		

Troffers — Glass Bottom

18	4.3	18	2.9		
3	6.0	3	3.1		
Aver.	5.2	Aver.	3.0		

Surface Mounted Fixtures — Glass Enclosed

4	3.7	4	1.9	4	2.1

tion, not only by the manufacturers in order to enhance their product, but also by those who use the fixtures in order to reduce their loss of investment by depreciation resulting from the accumulation of dirt on the fixtures.

Conclusions

It is recognized that this survey does not include an equal number of tests of louvered and glass bottom troffers, suspended and surface-mounted luminaires, and that therefore comparisons between classes can only be approximate. However, comparisons among the many suspended fixtures should be more significant.

Bearing the above in mind, it is believed that the following conclusions are reasonable:

1. The rate of depreciation of fluorescent fixtures varies considerably for different classes of fixtures and for different fixtures of the same class but of different manufacture.

2. The rate of depreciation of fluorescent fixtures varies, and in general decreases (but not in all cases), as the operating time increases.

3. On the average, this survey suggests the following order of increasing depreciation rate among classes of fixtures.

Period of Months

3	8	14.5
Troffers—Louvered	Suspended—Louvered	Suspended—Louvered
Suspended—Louvered	Troffers—Louvered	Surface—Glass Bottom
Surface—Glass Bottom	Surface—Glass Bottom	Suspended—Glass Bottom
Suspended—Glass Bottom	Troffers—Glass Bottom	
Troffers—Glass Bottom	Suspended—Glass Bottom	

4. It would seem desirable to have more data on depreciation rates. The ease with which the above data was obtained, once the planning had been completed, warrants additional similar programs to help evaluate these factors under various situations. Any lighting installation could be used for such a purpose and the results if properly evaluated would benefit future designers of fixtures and lighting systems.

Acknowledgment

The data presented in this paper would be unavailable were it not for the enthusiastic cooperation of Messrs. R. E. Colwell, W. L. Hawthorne, L. A. Fulcher, J. W. French and E. L. Munday, Jr., in conducting the lighting surveys. All of these men are with the Appalachian Electric Power Company. Mr. G. J. Taylor of Daybrite Lighting, Inc., was very helpful with the initial planning of the survey and procedure.

Printed sets of Conference papers will be available at the I.E.S. National Technical Conference, September 8-12, Edgewater Beach Hotel, Chicago, Illinois. $1.00 per set at Chicago. $1.50 per set by mail direct from Society Headquarters.

Lighting A Policeman

THE TITLE of this installation is not as facetious as it may sound. That was precisely the assignment given the local utility engineers by the Brentwood, Missouri, Police Department—high level lighting for the safety of the traffic officer at an especially hazardous intersection.

Jurisdiction for the dangerous corner—a major traffic artery intersection on U.S. Highway 40—is shared by Brentwood and the City of Richmond Heights, Missouri, suburbs of St. Louis. Increasing traffic made police direction on the one hand more than ever necessary for traffic safety, and on the other hand, a danger to the officer on duty. Several near casualties to police personnel resulted in joint municipal action.

The solution is simple—but effective and somewhat unusual. A 500-watt R-40 reflector spotlamp is mounted 16 feet above the roadway, in a die-cast aluminum street light hood on cross suspension cables, placing the luminaire directly above the officer's head. A white circle six feet in diameter is painted on the highway directly under the light.

Illumination readings on the roadway in concentric circles were measured as follows:

In the center of the spot—1 ft 4″ in diameter	120 ft-c
In the next circle—2 ft 6″ in diameter	100 ft-c
In the next circle—3 ft 8″ in diameter	85 ft-c
In the next circle—5 ft in diameter	60 f-tc

The traffic officer shown in the photograph is wearing a light grey-blue jacket and darker blue trousers. Brightness meter readings were taken as follows:

On the cap	210 ft-c	
Shoulders	180 "	75 ft-L
Upper forearm	100 "	42 "
White gloves beckoning traffic to proceed	125 "	100 "
White gloves directing traffic through	60 "	50 "

As evidenced by correspondence received by the utility, the idea has pleased the municipal officials, the police chief, and especially Patrolman Stewart Ducey, who was most personally involved. In addition, the installation won a Merit Award for Carter Lewis of the Union Electric Co. of Missouri, St. Louis, at the Fourth International Lighting Exposition in Cleveland in May, his Entry No. 543.

Visual Importance of the Spectral Components of White Light

By D. Y. SOLANDT
R. L. WHITE
P. S. ROSEN

This paper reports the results of I.E.S. Research Fund Project No. 16. These experiments show no significant difference in visual acuity under white illumination of seven different spectral compositions.

MANY investigators have assessed the visual acuity of the eye using a variety of monochromatic illuminants. Konig,[1] Gullstrand,[2] Ferree and Rand,[3] and Roaf,[4] using colored illuminants of approximately equal energy content, concurred in concluding that visual acuity is at a minimum using blue light and is poorer with red light than with light of a color (green, yellow) found in the central region of the visible spectrum. Schlaer, Smith and Chase,[5] using the Landolt C test object, obtained substantially the same values for visual acuity using white, red, yellow and blue lights if the intensities of the illuminants were adjusted to give equal brightness values of the test object, rather than to provide similar values of energy incident on the test object. Hartridge[6] also found visual acuity to vary but little using lights of different spectral colors, providing the same test object brightness values could be achieved with each of the various illuminants tested.

The results of these experiments, using a series of single illuminants which provided a narrow band of radiation yielding light of a single color, give no information concerning the visual effectiveness of spectral mixtures. Schwartz and Allen[7] observed that light of one color may stimulate or inhibit the response to another color. Thus, it is claimed that any mixture of spectral colors may give rise to complicated interactions which cannot be predicted on the basis of studies using monochromatic stimuli. The recent work of Simonson and Brozek[8] and von Bahr[9] indicate the dangers of such extrapolation. They may be interpreted as supporting this hypothesis of unpredictability of the visual response to polychromatic illumination.

The experiments described in the present communication were undertaken to assess human vision under white light from an incandescent source, and that produced by various mixtures of bands of complementary spectral colors.

The studies completed to date were undertaken to provide the information essential to the initiation of investigations designed to establish the visually optimal spectral composition of white light. The results of the present experiments indicate that a single optimum formula for the spectral composition of ideal white light may not exist. An attempt will also be made to determine the minimal spectral representation in white light which will permit maximal visual performance. The effect on the parameters of vision of qualitative deletions and substitutions, and quantitative variations which are possible in the spectral composition of white light will be measured. Rather than assessing the visual adequacy of white lights of differing spectral composition, as in the present experiments, the spectral components essential to maximal visual performance will be determined.

Methods

A. The Apparatus

The Landolt broken ring was employed as the test character, and a series of these was reproduced photographically on high-contrast 3¼ by 3¼ inch lantern slide plates (Fig. 1). The break, or gap, in the ring constitutes the point of critical detail. This gap was made square in outline by giving the solid line forming the test character the same thickness as the gap dimension. The total diameter of the test character was always five times the gap dimension.

Before reproducing a full series of test objects, a number of trials were performed to determine the

Figure 1. Test object slide with Landolt C test character.

AUTHORS: Dept. of Physiological Hygiene, School of Hygiene, University of Toronto; assisted by a grant from the Illuminating Engineering Society Research Fund.

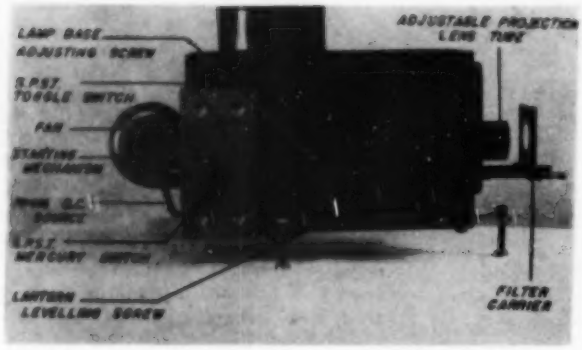

Figure 2. Projection lantern. Lantern houses concentrated (zirconium) arc lamp with cooling fan, electrical controls, and optical apparatus for filtering and focussing the resulting monochromatic light on test screen.

smallest size of test character with which each subject gave correct answers for all the presentations in the series comprising a single trial. This requirement was fulfilled for all subjects by a test character with a gap dimension of 0.52 mm. It was found that a reduction of 0.03 mm in the gap from this critical size produced changes in individual performance, and a marked spread in the performance of the groups of subjects. In practice, trials were initiated with a test character having a gap dimension of over 0.60 mm. The several series of such test characters used provided for a suitable reduction in the gap dimension over the region of critical size.

With the photographic techniques available, it was not possible to produce a series of the test characters having equal steps in the gap dimension and precise to within the required 0.005 mm. In practice, a large number of test objects were produced with the size of the test character covering the desired range. The gap of each was then measured under a travelling microscope. A group of test objects providing a series of test characters with a suitable range of gap dimensions was chosen as listed in Table I.

Three separate 100-watt concentrated (zirconium) arc lamps, each housed in a specially constructed projection lantern (Fig. 2), were used as sources for the lights of complementary colors. Each lamp is mounted horizontally on an adjustable base, permitting positioning of the light spot with respect to the optical system. The high-voltage starting mechanism is contained in a metal box attached to one side of each lantern and a cooling fan is mounted on the rear wall of each lamphouse. It was found essential that the line supplying electric power to the lanterns be sufficiently heavy to provide the full current required by all three lanterns without any mutual interference and its resulting reduction in lamp intensity.

In each lantern light from the arc lamp is collimated by a condensing lens and then passes through the projection lens and the filter (when used) before illuminating the test screen. The brightness of this screen may be adjusted by adjusting the position of the projection lens to produce variations in the area covered by the light beam.

In the present experiments the three projection lanterns were arranged to cast their beams on the same area on the rear surface of the test screen. The test screen was built as a small window of opal glass held in an aperture in the wall which separated the subject from the light-producing equipment (Fig. 3). The front surface of this screen was masked by a carrier designed to hold a standard lantern slide. A test character reproduced on such a slide would thus appear as a black figure in the center of a circular bright area 52 mm in diameter.

Two mixtures of monochromatic lights were obtained by the use of suitable filters in the lanterns. The relative intensities of the two or three monochromatic beams were adjusted so that the illumination seen on the front surface of the screen appeared white. In all such cases, the validity of the sensation of white was verified by establishing the presence of a black after-image. The dichromatic mixture producing white light was achieved by

TABLE I.—Test Character Critical Detail Dimensions of Series of Test Objects Used.

Landolt Ring Gap Width (mm.)	Visual Angle Subtended by Gap (at 3 meters)
0.62	43.2 sec.
0.58	39.9
0.52	35.7
0.49	33.9
0.47	32.2
0.41	28.2
0.40	27.5
0.38	26.1
0.34	23.3
0.25	17.2

TABLE II.—Test Screen Brightness.

Experiment	Illuminant	Symbol	Mean* Test Screen Brightness (Footlamberts)
I, II	Open fluorescent lamp	A	10.2
I, II	Lanterns (2) giving yellow and blue-green dichromatic mixture	B	10.2
I, II	Open 100-watt (zirconium) concentrated arc lamp	C	10.3
I, II	Lanterns (3) giving orange, green and blue trichromatic mixture	D	10.2
III, IV	Tungsten filament incandescent lamp	A'	10.1
III, IV	Mixture of radiations from a sodium and mercury lamp	B'	10.1
III, IV	Open fluorescent lamp	C'	10.2
III, IV	Mercury lamp with yellow filter	D'	10.1

*These values are each the arithmetic mean of ten consecutive determinations, the spread of which was never greater than ±2%.

using a yellow filter (540 to 670 mμ) on one lantern, and a blue-green filter (450 to 600 mμ) on the other. Similarly, the trichromatic mixture yielding white light was achieved by employing one lantern equipped with an orange filter (560 to 700 mμ), a second with a green filter (500 to 660 mμ), and the third with a blue filter (420 to 510 mμ).

The other illuminants employed were a 100-watt (zirconium) concentrated arc lamp*, a 100-watt tungsten filament incandescent lamp, a 25-watt white circular fluorescent lamp, a sodium vapor arc lamp (NA-9), and a mercury vapor arc lamp (A-H4)**. These sources were employed in open mounts with no other optical apparatus employed except the yellow filter interposed between the mercury lamp and the test screen in the case of the illuminant D' (see Table II). The intensity of the test screen illumination was adjusted by varying the source-to-screen distance in using each of these illuminants.

The brightness of the front of the opal glass test screen was standardized at approximately 10 footlamberts. The test character itself appeared black with a bright gap (critical detail) and a bright central region. Ten consecutive brightness determinations were made with a Luckiesh-Taylor brightness meter,[10] and the mean of these taken as the brightness value of the test screen. This procedure was repeated each day and the brightness value quickly re-checked prior to each set of visual acuity measurements during each experiment. Thus checked and re-checked, brightness of the test screens using the four types of light were found to lie within less than two per cent of each other, as shown in Table II in which a typical set of results is given.

*Western Union Telegraph Company.
**All except zirconium arc lamp manufactured by the General Electric Company.

With the brightness adjusted to 10 footlamberts, the spectral energy at the front surface of the test screen was measured through the use of a spectrograph covering the visible spectrum and employing a replica grating for the spectral dispersion of light admitted by the 2.5 mm entrance slit. Light leaving the exit slit of the apparatus had an effective spectral band width of 10 millimicrons. This was arranged to excite a phototube, two of which were employed to cover the visible spectrum. The phototube output was passed into the balanced input circuit of a single-stage direct current amplifier which actuated a sensitive galvanometer. The calibration of the phototube, amplifier, galvanometer assembly was carried out with reference to the spectral distribution curve of the 100-watt concentrated arc lamp as published by the manufacturer*.

The spectral energy distribution of each of the four types of illuminant used was precisely mapped by measuring the energy present in each 10 millimicron band over the range of visible radiations. This procedure was repeated three times for each type of light studied. The means of these values were then corrected for the sensitivity of the phototubes. The resulting spectral energy distribution curves are shown in Fig. 4, and agree well with such published data on similar illuminants as have appeared in the literature. Fig. 5 shows illuminant data for Experiments III and IV.

The spectral distribution curve for the zirconium arc and tungsten filament incandescent lamps are continuous, that for the fluorescent lamp shows the peaks characteristic of the mercury arc (low voltage) superimposed on the relatively continuous spectrum achieved by the balanced mixture of fluorescent materials in the phosphor. The dichromatic illumination shows energy maxima at two peaks and the trichromatic, similarly, at three peaks situated in the spectrum at points deter-

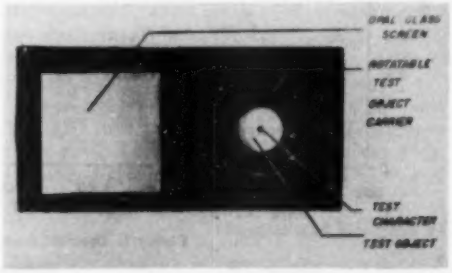

Figure 3. Test screen with door—test object in place. Door carrier for test object in open position. In use, this door covers the test screen which provides illumination for the test object giving a bright background to the Landolt C test character.

mined by the filters used. The sodium and mercury vapor arc lamps show the discontinuous spectra characterized by a few high-energy peaks typical of these illuminants.

The brightness of the major surround (the visual field around the test screen) was relatively uniform and at a level of approximately two foot-lamberts. This was accomplished by providing

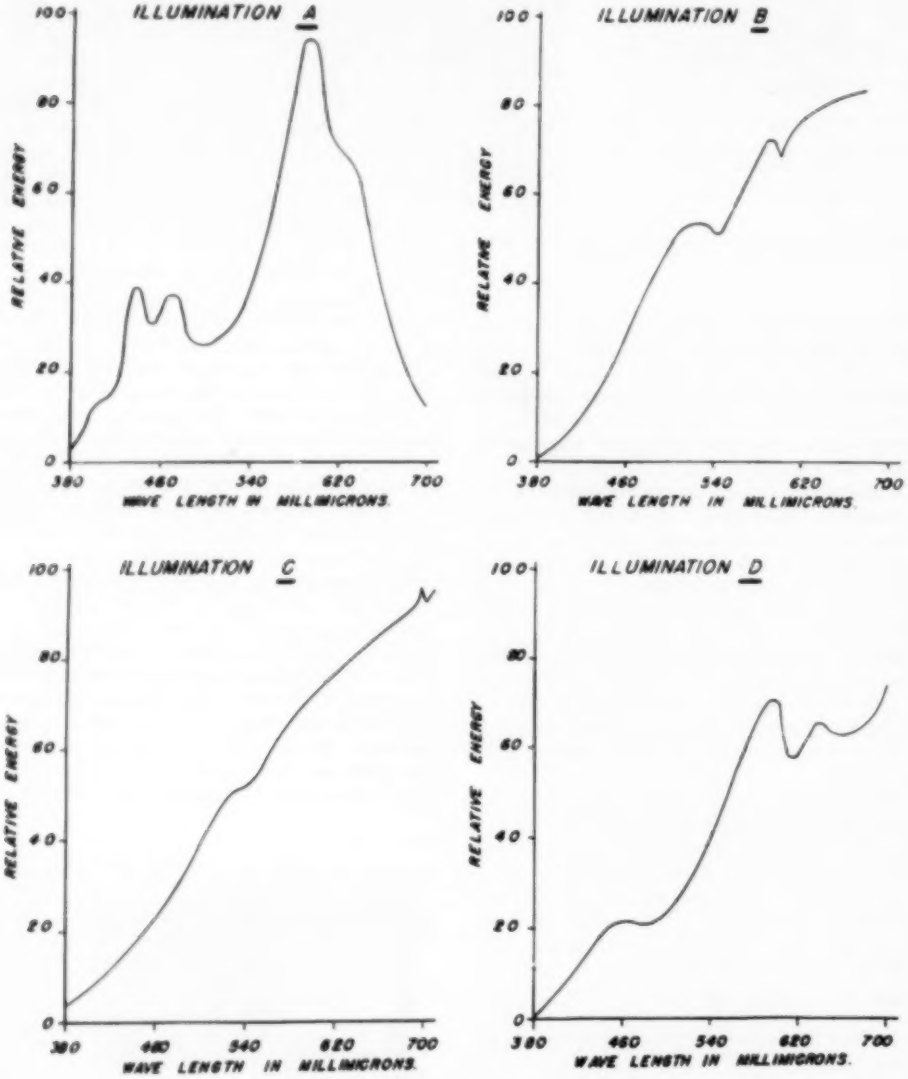

Figure 4. Spectral representation of four illuminants.

Illumination	Illuminant
A	Fluorescent lamp
B	Lanterns (2) with monochromatic filters giving dichromatic mixture
C	Concentrated (zirconium) arc lamp
D	Lanterns (3) with monochromatic filters giving trichromatic mixture

Illuminant

TABLE III.—Latin Square Design of an Experiment.

	1	2	3	4
a	A	B	C	D
b	B	D	A	C
c	C	A	D	B
d	D	C	B	A

The order of presentation of illuminations is read from left to right in each row.

NOTE: This is the design for Experiment I; the variations employed in experiments II, III, and IV are indicated in the following table.

Variable	Experiment I				II			
Subjects:	a,	b,	c,	d	a',	b',	c',	d'
Order of Presentation:	1,	2,	3,	4	1,	2,	3,	4
Type of Illuminant:	A,	B,	C,	D	A,	B,	C,	D
	III				IV			
Subjects:	a,	b,	c,	d	a,	b,	c,	d
Order of Presentation:	1,	2,	3,	4	1,	2,	3,	4
Type of Illuminant:	A',	B',	C',	D'	A',	B',	C',	D'

Where the illuminants represented by the symbols are:
A — Fluorescent lamp;
B — Dichromatic Mixture; yellow (540-670 mu) and blue-green (450-600 mu)
C — Zirconium arc lamp;
D — Trichromatic Mixture; orange (560-700 mu), green (500-660 mu), blue 420-510 mu)
A'— Tungsten filament incandescent lamp
B'— Combined radiations from sodium and mercury arc lamps
C'— Open fluorescent lamp
D'— Mercury arc lamp with yellow filter.

shielded portable room lights placed remote from the test screen, and by using a test room with black walls and a high ceiling to facilitate the control of stray light.

B. Test Procedures

The observers used in these experiments all had 20/20 visual acuity for each and both eyes, and were recruited from the scientific personnel of the Department. All were given an initial practice session designed to achieve a common level of experience in making the psycho-physical judgments involved in the test procedure. In a complete series of experiments, each of four observers judged the positions of the gap in the Landolt ring under four different types of illuminations in each experiment.

The method of test employed throughout was to present a single Landolt broken circle to the subject, who was asked to identify which of eight positions was occupied by the gap (*i.e.*, up, down, right, left, right up, right down, left up, left down). One slide at a time was inserted in the special carrier in the door covering the opal glass screen. Readings were taken in groups of eight for each size of gap. The slides were employed in descending series with respect to the size of the test character. The distance between test object and subject was constant throughout the experiment. The subject sat with his face in a chin-rest at a viewing distance of three meters from the test character. The measurements were binocular and natural pupils were used.

The Latin Square design was used in all experiments, and the data from the similar experiments in each series combined from the paired Latin Squares for purposes of analysis. In all tabulation the subjects are represented by small letters (Group 1 by a, b, c, and d; Group 2 by a', b', c', d'), the order of presentation by arabic numerals (1, 2, 3, 4), and the illuminations by capital letters (A, B, C, D, and A', B', C', D'). Each box represents the combination of observer, order of presentation and illumination under which the data were collected. A four by four Latin Square design as shown resulted in a different order of use of each type of illuminant with each observer, thus balancing out the effect of learning and other possible phenomena, the effects of which may change from session to session. This method permits the separate consideration of order effects, illumination effects, and the observed inter-subject differences by subjecting the experimental data to an analysis of variance.

Initially, four spectrally different types of illuminants (A, B, C, D—see Table III) were evaluated (Tables IV and V) in Experiments I and II, with different observers (Group 1 and Group 2) in each experiment. Only one subject was tested on any single day. The experiments were performed in the morning with the testing sessions beginning at about 9:30 a.m. (approximately ninety minutes after breakfast). Each group of observations occupied about twenty minutes and four such groups were completed at a single session, with an half-hour rest period provided between groups.

A second group of illuminants (A' B', C', D'—see Table III) was similarly assessed in Experiment III, of which Experiment IV was a replication using the same group of subjects. (See Tables VI and VII.)

Results and Conclusions

In all visual acuity determinations, it is difficult to obtain a sharp end-point because of the effects of chance, inattention and fatigue. In the present studies, using the Landolt broken ring as test character, there were eight different possible positions of the gap for any one presentation. Thus, there

was a one-in-eight chance of giving a correct answer which might not otherwise be made. As the angle subtended by the test character is reduced, it becomes increasingly difficult for the subject to make correct judgments. Inter-ocular muscle balance, fixation and pupillary and lens adjustments of the individual eyes must all be made and maintained with increasing precision as the retinal dimensions of the critical detail under examination are decreased. Fatigue and inattention, separately or in

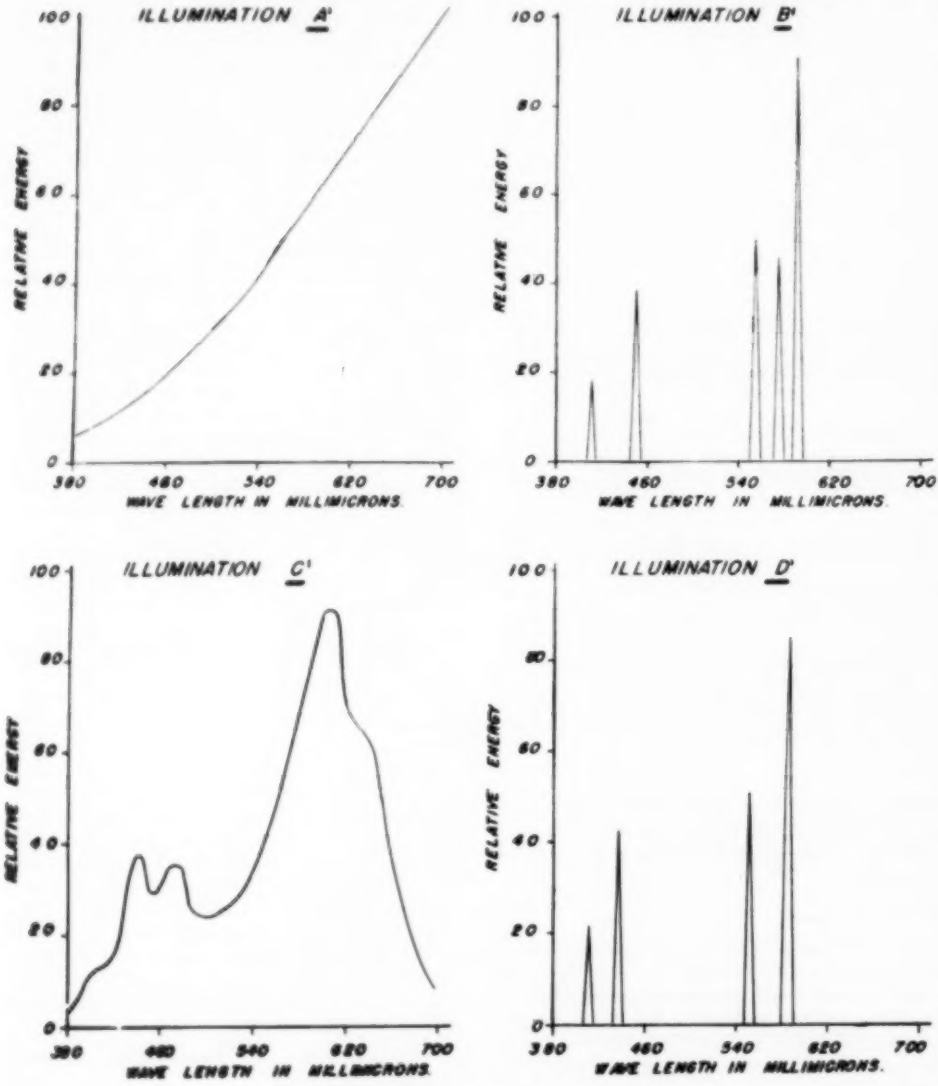

Figure 5. Spectral representation of four illuminants.

Illumination	
A'	Tungsten filament incandescent lamp
B'	Combined radiations from sodium and mercury arc lamps
C'	Open fluorescent lamp
D'	Mercury arc lamp with yellow filter

TABLE IV.

EXPERIMENT I.—Results of Visual Acuity Threshold Determinations.

Subject	Order of Presentation 1	2	3	4	Total
a	A .396	B .421	C .448	D .411	1.676
b	B .403	D .429	A .409	C .439	1.741
c	C .341	A .333	D .345	B .394	1.413
d	D .407	C .431	B .407	A .437	1.682
Total	1.547	1.684	1.609	1.681	6.512

The visual acuity thresholds (experimental data treated by the Karber Method — see Table VIII) as determined for each of four illuminants are listed for each subject and in the order of testing. Thresholds are stated as the test character gap dimension in millimeters and are tabulated in the "Latin Square" plan (see Table III) with the statistical treatment in Table IX.

TABLE V.

EXPERIMENT II.—Results of Visual Acuity Threshold Determinations.

Subject	Order of Presentation 1	2	3	4	Total
a'	A .301	B .333	C .340	D .412	1.386
b'	B .411	D .333	A .403	C .407	1.554
c'	C .308	A .370	D .383	B .411	1.472
d'	D .344	C .314	B .333	A .346	1.337
Total	1.364	1.350	1.459	1.576	5.749

This experiment was performed in a manner identical to that of Experiment I (see Table IV) but using different subjects.

TABLE VI.

EXPERIMENT III.—Results of Visual Acuity Threshold Determinations.

Subject	Order of Presentation 1	2	3	4	Total
a	A' .356	B' .346	C' .379	D' .469	1.550
b	B' .350	D' .284	A' .431	C' .404	1.569
c	C' .325	A' .310	D' .276	B' .329	1.240
d	D' .422	C' .390	B' .366	A' .396	1.574
Total	1.453	1.430	1.452	1.598	5.933

This experiment was performed in a manner identical to that of Experiment I (see Table IV) but using different subjects. (For statistical treatment see Table X.)

TABLE VII.

EXPERIMENT IV.—Replication of Experiment III. Results of Visual Acuity Threshold Determinations.

Subject	Order of Presentation 1	2	3	4	Total
a	A' .406	B' .329	C' .318	D' .308	1.361
b	B' .426	D' .411	A' .450	C' .434	1.721
c	C' .446	A' .356	D' .329	B' .285	1.316
d	D' .383	C' .379	B' .349	A' .320	1.431
Total	1.561	1.475	1.446	1.347	5.829

This experiment was performed in a manner identical to that of Experiment I (see Table IV) but using different subjects. (For statistical treatment see Table X.)

combination, may thus give rise to random errors under conditions well above the visual acuity threshold. Such mistakes often do not increase in a regular manner with decrease in the visual angle. In order to determine the level of size of the critical detail at which the subject is identifying correctly 50 per cent of the positions of the gap, it is necessary that these factors be considered.

Since the present study was concerned with relative values rather than the absolute dimensions of visual acuity, it was appropriate to use the Latin Square form of design for the experiments and to calculate the individual thresholds by the Karber method.[11] The values yielded were checked using a provisional probit line, and no significant discrepancies were found. A typical calculation of an individual threshold using the Karber method is given in detail in Table VIII.

The results of Experiments I and II are analyzed in Table IX which carries all the statistical material derived from the visual acuity data listed in

TABLE VIII.—Example of the Calculation of An Individual Visual Acuity Threshold.

Method of Karber[11] applied to the data for Subject C' with Illuminant A (Table V)

Size of Critical Detail (Landolt Ring Gap)	Performance (number of correct answers) / (number of trials)	$p = \frac{x-1}{8-1}$	$p_i - p_{i-1}$	$\frac{x_i + x_{i-1}}{2}$
0.52 mm.	8/8	7/7	0/7	
0.49	8/8	7/7	0/7	1.01/2
0.47	7/8	6/7	1/7	0.96/2
0.41	6/8	5/7	1/7	0.88/2
0.40	6/8	5/7	0/7	0.81/2
0.38	6/8	5/7	0/7	0.78/2
0.34	3/8	2/7	3/7	0.72/2
0.25	1/8	0/7	2/7	0.59/2

$$ED_{50} = \Sigma p_i - p_{i-1} \frac{x_i + x_{i-1}}{2}$$

$$= 1/14\,[0.96 - 0.88 - 3(0.72) - 2(0.59)]$$

$$= 0.370$$

Where: ED_{50} is the visual acuity threshold expressed as the Landolt C gap dimension (in mm) in the test character for which 50% of the responses were correct.

p_i is the proportion of corrected responses (corrected for chance) for test character with gap i.

x_i is the dimension of gap i in mm.

Tables IV and V. Inspection of these tables indicates that visual acuity is not, under the conditions of these experiments, dependent on the spectral composition of white light. No significant differences in visual acuity were found for the four spectrally dissimilar types of white light tested. Order of presentation and type of illuminant used also showed no statistically significant changes. The inter-subject differences were significant as might be expected. It will be noted (Fig. 4) that, while all the illuminants showed marked differences in spectral composition, only the fluorescent lamp achieved marked and localized peaks in the emitted visible radiant energy. The band width of the filters used for the dichromatic and trichromatic combinations was so great that these mixtures yielded a continuous spectrum with a small peak for each monochromatic filter used. The illuminant under test was always operated at a high intensity level in an attempt to eliminate the troublesome visual acuity variations which can result from small changes in illuminant intensity when this value is adjusted at or near the optimum level.

TABLE IX.—Analysis of Variance.

Calculations based on the combined data from Experiments I and II. (See Tables IV and V.)

	Degrees of Freedom	Mean Square of Differences	F Ratio Calculated from Present Data	F Ratio Critical Value for Significance at 5% Level	Significant at 5% Level
Subjects	7	.005875	5.77	2.58	yes
Order	3	.002566	2.52	3.16	no
Illumination	3	.000611	0.60	3.16	no
Error	18	.001019			

From the above data and using the mean values for the individual visual acuity thresholds (data from Tables IV and V which have been treated by the Karber Method — Table VIII) of the eight subjects used in Experiments I and II, the difference in threshold values under the four illuminants used necessary for significance at the 5% level has been determined.

		ILLUMINANT A	B	C	D	Significant at 5% Level
Mean of individual visual acuity values (data of Tables IV and V treated by Karber Method — Table VIII) of eight subjects		0.373	0.389	0.378	0.392	
Differences involving	A	———	0.016	0.005	0.019	no
	B	0.016	———	0.011	0.003	no
	C	0.005	0.011	———	0.014	no
	D	0.019	0.003	0.014	———	no

Necessary difference for significance at 5% level 0.034

TABLE X.—Analysis of Variance.

Calculations based on the combined data from Experiments III and IV. (See Tables VI and VII.)

	Degrees of Freedom	Mean Square of Differences	F Ratio Calculated from Present Data	F Ratio Critical Value for Significance at 5% Level	Significant at 5% Level
Subjects	7	.006430	5.02	2.58	yes
Order	3	.000354	0.28	3.16	no
Illumination	3	.001492	1.17	3.16	no
Error	18	.001280			

The mean values of the threshold determinations under the four types of illuminants and for the four subjects (each tested twice) investigated are shown below. These are derived from the data of Tables VI and VII. The necessary difference for significance at the 5% level was determined from the above data.

		ILLUMINANT A	B	C	D	Significant at 5% Level
Mean of individual visual acuity values		0.378	0.348	0.372	0.373	
Differences involving	A	———	0.030	0.006	0.005	no
	B	0.030	———	0.024	0.025	no
	C	0.006	0.024	———	0.001	no
	D	0.005	0.025	0.001	———	no

Necessary difference for significance at 5% level 0.038

The illuminants used (Table III and Fig. 5) include the tungsten filament incandescent lamp with its emission showing the typical smoothly continuous spectrum which includes representation from the entire range of visible radiations, and the sodium and mercury vapor arc lamps with their output showing the completely discontinuous spectrum typical of this type of illuminant.

Although these illuminants are spectrally maximally dissimilar, and much less alike than those employed in Experiments I and II, nevertheless, the results are similar in that there is no significant difference in visual acuity resulting from the nature of the spectral composition of the white lights used. Only the inter-subject differences achieve significance at the 5 per cent level.

Summary

1. Seven types of illumination, each giving the sensation of white light, but differing, chiefly quantitatively, in spectral composition could be applied separately to the rear surface of an opal glass plate. The front surface of this plate as viewed by the subject formed the test screen. With the brightness of this test screen standardized at ten footlamberts for each type of light, the spectral energy curve for each illuminant was measured at the front surface of the test screen.

2. Visual acuity was assessed using a series of lantern slides as test objects with a single Landolt broken ring as test character on each slide. The size of the test character and the gap in the ring (point of critical detail) differed on each slide. The slides were presented to the subject in descending order of critical detail dimension by placing them in a special carrier inserted in the center of a door covering the front surface of the viewing screen. Each subject was seated at a distance of three me-

ters from the screen, and, using both eyes with natural pupils, was asked to identify which of eight possible positions was occupied by the gap in the test character. This orientation was varied at random as the slides in the test series were presented.

3. Each of the four experiments was carried out according to the statistically logical plan of the four by four Latin Square design. This resulted in a different order of presentation of the four types of illumination to four observers used in each experiment. The effects of learning and unknown extraneous influences which might vary from time to time were eliminated by this procedure. The same illuminants were used in each of two of the four experiments, and the data from the two Latin Squares were combined for analysis. This method permits separate treatment of the data for assessment of order effects, illumination effects and inter-subject differences using "Analysis of Variance."

4. All the illuminants used were adjusted to give white light as verified by a black after-image, and with the intensities of all adjusted to yield equal brightness of the test screen. No significant difference in visual acuity was seen in connection with any of the seven illuminants tested, in spite of the dissimilar spectral composition of the white light produced by each type of illumination. The visual effectiveness of white light appears to depend on its brightness, and not on the continuity, discontinuity, or spectral location of the visible radiant energy responsible for the illumination.

5. Proposals are made for further studies comparing the visual effectiveness of white light produced by incandescent sources; and by mixtures of very narrow bands of complementary colors achieving a true discontinuous spectrum, when the illuminant intensities are equated on the basis of energy values rather than brightness observations. That the determination of minimal spectral requirements of white light is necessary for maximal visual acuity or optimal visual performance is suggested as another experimental approach to the assessment of the visual role of the spectral components of white light.

Acknowledgments

The authors are especially indebted to Mr. C. L. Crouch, Secretary of the Illuminating Engineering Society Research Fund; to Mr. Ward Harrison, Chairman of the Research Executive Committee; and to Professor E. M. Strong, President-Elect of the Illuminating Engineering Society, for invaluable advice and assistance both in the initiation and prosecution of this investigation. Mr. D. B. W. Reid, Assistant Professor of Biometrics (Department of Epidemiology and Biometrics, School of Hygiene, University of Toronto) gave invaluable advice and assistance with the statistical aspects of the study. The authors are indebted to Miss E. R. Mills for undertaking the bibliographic and secretarial work, and to Mr. John H. Horwood for providing technical assistance essential to this investigation. Thanks are also due to the many members of the School of Hygiene staff who served as subjects for this work.

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DISCUSSION

E. SIMONSON*: The work of Dr. Solandt *et al* is a very interesting study in an area where further research is much needed. On the surface, it might appear that there is a contradiction between their results and ours. Dr. Solandt found no effect of the spectral composition of white light, while we obtained, in several items, statistically significant differentiation between three illuminants emitting white light of somewhat different spectral distribution. Actually, there is no contradiction. Dr. Solandt investigated visual acuity only. We also found no effect of spectral composition of white light on visual acuity. However, we found a differentiation in several visual functions during prolonged strenuous visual work, performed in the conditions of a "miniature job situation." We are glad to hear that Dr. Solandt is aware of this situation, and that he plans to study visual performance. It may also be pointed out that the spectral mixtures in our experiments and in Dr. Solandt's experiments were not identical. We compared a greenish lamp (Verd-A-Ray), a bluish lamp (Opal glass), and the ordinary inside frosted lamp. The spectral differences were slight, but could be safely differentiated by the observers. It would be interesting to know whether this was the case also with the spectral mixtures in Dr. Solandt's experiments.

While we are ready to accept Dr. Solandt's experiments as consistent with ours, there are several points in his experimental setup and evaluation which need discussion. Dr. Solandt used an eight step visual acuity test and claims that such arrangement cuts down the chance factor for the correct identification to 1:8. However, this is the case only when all steps are in the critical zone of recognition or uncertainty. Obviously, the number of steps could be indefinitely enlarged in both directions, by adding large details which can be instantaneously identified, or microscopic details, which nobody could recognize. This means the absolute number of steps has no bearing on the coefficient of change distribution. Dr. Solandt's largest and smallest size must have exceeded the recognition limits for *all* subjects, otherwise a calculation of the mean acuity would not be possible. For the individual subject, the number of critical steps was

*University of Minnesota.

probably even less than six, for instance in the example in his Table VI it was four rather than six. A chance factor of 1:4 for correct recognition might easily obscure slight differences. A continuous acuity scale, such as developed by Hecht and Schlaer for the Landolt ring or by Luckiesh and associates for the double bar test would be definitely superior.

ARTHUR A. EASTMAN*: Dr. Solandt's paper is a further contribution to the knowledge we have of the effect of the spectral quality of light on visual acuity. Using a different approach, he confirms the work of other investigators who have found no significant differences in visual acuity with various so-called white illuminants. However, where color contrasts or color discrimination is involved, relatively small spectral differences in illuminants may become important.

Dr. Solandt's use of the black after-image in determining the whiteness of his color mixtures is a unique approach. It would be interesting if Dr. Solandt would comment on his experience as to the time involved and the consistency of results in using such a criterion, which would appear to be difficult to apply because of the inherent variability of the after-image response.

D. V. SOLANDT**: The work of Drs. Simonson and Brozek referred to did not involve illuminants yielding white light, nor did the illuminants used differ in spectral content to a degree, or in a manner designed to make their comparison a logical procedure.

The precision of the statistical evaluation of the results of the present study is facilitated by the use of the graded visual acuity test. The many complex and interrelated variables present in the gross visual performance test render this method of evaluation an inadequate substitute for the determination of separate and well-defined parameters of vision. Even such a measurable parameter as visual acuity cannot be determined with a degree of precision justifying a continuous scale of performance. As Dr. Simonson has so clearly pointed out, the number of steps that can, with validity, be included in the performance scale are frequently so few as to give the element of chance undesirable but unavoidable importance.

I am grateful to Mr. Eastman for his words of caution against the unjustified extension of the results of the present study to include those instances where slight spectral differences have great visual importance. His remarks on the generally accepted variability of the after-image response are also most pertinent. This response was found usable for the purpose of identifying white light by the rigid standardization of the conditions of observation and adoption of fixed forms descriptive of the response of the subject. Much of the variability was found to be apparent and not real, when these sources of spurious differences were eliminated.

*General Electric Co., Nela Park.
**Author.

Color Balance for Ladies Wear

The planning of this lighting installation, at Day's Fashion Shop, Detroit, Mich., was aimed at achieving a balance of incandescent and fluorescent light for good color rendition of merchandise and providing a high level of illumination.

Eight rows of louvered troffers are spaced 8 feet apart running at right angles to the length of the store. Each row consists of two 3-lamp troffers containing 96-inch 75-watt standard cool white lamps. Spaced midway between rows are 24 recessed incandescent units, three between each two rows. These have glass lenses and use 200-watt lamps. Valance lighting is produced by 40-watt fluorescent channels. Showcases are lighted with T8 slimline lamps in conventional showcase reflectors. The average illumination is 114 footcandles.

Installation designed by Charles L. Harris, Detroit Edison Co.; Electrical Contractor, Litt Electric Co., Detroit, Mich.

INSTALLATION AT BEXAR COUNTY COLISEUM, SAN ANTONIO, TEXAS

Lighting a Sports Arena

LIGHTING OBJECTIVE: To provide illumination for a variety of sporting events with a minimum of glare to the spectators, using easily maintained lighting equipment.

GENERAL INFORMATION: The arena floor is an oval 248 feet long and 123 feet high. Height to catwalks is 70 feet. The walls are rough gray concrete; ceiling is constructed of white wood planks; the walkway and concourse flooring is black asphalt and the arena floor is brown dirt.

INSTALLATION: The installation consists of 51 Holophane Hibay No. 691-AL-HS 1500-watt units in the center section of the arena, mounted 70 feet from floor. At the midpoint of this area, boxing ring lights are mounted on a 12-foot square frame which is raised and lowered by a motor driven winch. This frame contains four No. 691-AL-HS 1500-watt and four No. 691-AL 1000-watt luminaires. In the oval bay over the box seats are 34 No. 691-AL 1000-watt units mounted at 70 feet, and over the general seating area (46-foot mounting) are 33 Lobay No. 685-AL reflectors with 500-watt lamps. The Hibay units in the center area are serviced from a catwalk; in the bays over the seating area Thompson disconnecting and lowering hangers are used. All units have large openings around the neck of the reflector for flue action in retarding dirt deposit.

The resultant average illumination on a plane 30 inches above the floor is 36 footcandles (after about 200 hours of use). At the center of the area, with the ring lights on in the raised (60-foot) position, the illumination is 58 footcandles; in the position for a boxing show (30-foot mounting) 75 footcandles result.

Architects: Phelps, Devine and Simmons; lighting engineered by Halsey and Royer, San Antonio, Texas.

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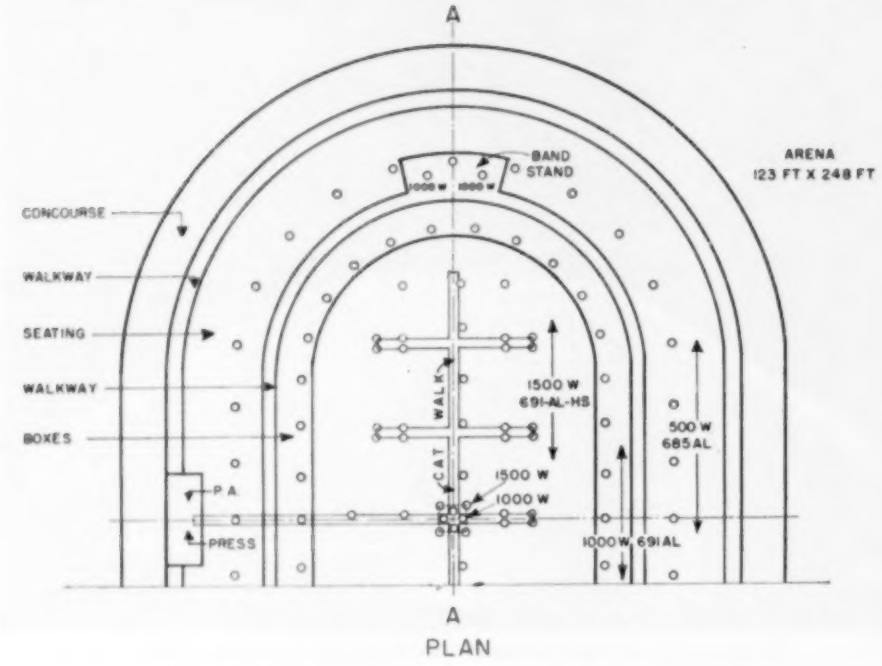

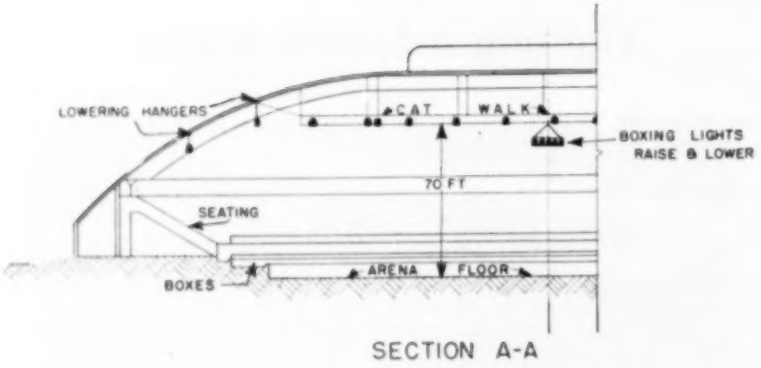

Lighting data submitted by Haley and Royer, Electrical and Mechanical Engineers, San Antonio, as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

"Production" Lighting for Chrysanthemums

By HUGH S. JAMES

PRODUCTION LIGHTING as applied to industry has a well-known connotation. In the installation shown, lighting was used to aid Nature in higher production of Chrysanthemum Pompons (Baby Mums). "Production" was increased from the normal one crop in the fall to three per year, with an improved product, and a wider market.

The installation was made by the largest wholesale cut flower grower in the east. In business since 1900, this grower has strived to improve the variety, quality and grade of cut flowers and control the growth in various seasons. Such planning assures a fresh product immediately available in the seasons when demands are greatest.

In the case of Baby Mums, a single crop for fall marketing was the usual practice. It was known, however, that this flower would have a good demand in other seasons, if daylight hours could be prolonged, to hasten stalk growth and retard early budding. This would approximate the normal growing conditions of the longer late summer days and keep the plant in succulent growth for a longer period, and producing a desirable longer stem and larger bloom. The aim for this project was out-of-season flowers with a large bloom and a 30-inch stem.

On 8-foot 3-inch centers, for the entire length of the greenhouse, clusters of two 300-watt R-40 reflector floodlights on flexible sockets are mounted on pipe uprights in the center of the greenhouse at a height of 11 feet above the floor. The greenhouse is 528 feet long by 40 feet wide and for this area 126 floodlights were used in 63 locations.

Sixty-seven thousand (67,000) seedlings were set on December 26, 1950, and the floodlights were used five hours per night until February 25, 1951. At the end of 52 days, or 260 hours, these flowers had a 25-inch stem and budding had been retarded during this period. Starting on March 1, the plants were shaded from 6:00 p.m. to 8:00 a.m. until April 17, 1951, when cutting was started. These flowers were marketed in several large cities throughout the country in time for Mothers' Day. The resultant demand, ready sale, and quality of subsequent crops of off-season growing has enabled the grower to provide three crops a year from one greenhouse.

AUTHOR: Duquesne Light Co., Pittsburgh, Pa. This installation won a Merit Award at the Fourth International Lighting Exposition May, 1952, as Entry No. 483.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Raddin, has prepared this listing of answers to frequently-asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

What is the purpose of silicone coating fluorescent lamps?

High relative humidity may cause some difficulty in starting instant start fluorescent lamps because the moisture along the outer surface of the lamps creates a leakage path of such value that starting is difficult.

Silicone coating as applied to fluorescent lamps is a very thin uniform transparent chemical coating applied to the outer surface of the lamps. This coating overcomes the surface leakage by causing the surface moisture to collect in droplets instead of a continuous film. This permits reliable starting even under high humidity conditions.

See page 8-52, *I.E.S. Lighting Handbook*, Second Edition.

What effect does ambient temperature higher or lower than normal room temperature (65-85F) have on incandescent filament lamp life?

Unlike fluorescent lamps, the light output of an incandescent lamp is relatively unaffected by changes in ambient temperature. Likewise, natural changes in ambient temperature (that is, from winter's lowest to summer's highest temperature) have little, if any, effect on incandescent lamp life. Operation of the usual type of incandescent lamp in enclosures where the increase in ambient temperature causes the base temperature to exceed approximately 175C (347F) may result in loosening of the base or melting of the lead-in wire solder.

Lamps with mechanical bases or bases employing high-temperature basing cement will withstand approximately 230C (446F). For lamps where base temperature is not a factor to be considered, temperature of the glass bulb is the limiting factor. The usual type of ordinary soft glass as found on standard general lighting service lamps should be operated under conditions where the glass does not exceed 300C (572F), while the maximum for the various hard or Pyrex-type bulbs ranges from 435C (815F) to 475C (887F).

For bake oven and similar high ambient temperature lighting applications there is available a line of "bake oven" lamps which employ the use of special high temperature solder and basing cement plus a special heat processing of the glass bulbs prior to lamp assembly. These lamps are recommended for use under conditions where the bulb temperature does not exceed 316C (600F).

Is it true that it requires as much electrical energy to start a preheat-type fluorescent lamp as to operate it for 15 minutes?

No. For example, it requires less watts to start a 40-watt preheat-type fluorescent lamp than it does to operate it. Since starting requires only two seconds or less the energy consumed in operating the 40-watt preheat lamp for 15 minutes is several hundred times the energy consumed in starting the lamp.

Why do some street series incandescent filament lamps have the same light output at the end of their life as initially?

Series lamps are usually operated on circuits that have automatic regulators to maintain constant current. During the life of an incandescent lamp, the filament becomes thinner, due to evaporation of tungsten, and its resistance therefore increases. With constant current, this increase in resistance results in an increase in wattage and operating efficiency, consequently an increase in the lumens generated by the filament. This increase in generated lumens may not be realized fully as an increase in the light output from the lamp because of bulb blackening.

Proposed American Standard Practice For Street and Highway Lighting

This American Standard Practice for Street and Highway Lighting* has been proposed as a proprietary Standard under the rules of procedure of the American Standards Association and under the sponsorship of the Illuminating Engineering Society. It represents considerable refinement in defining the classification of luminaire light distributions and the pictorial presentation; improved treatment of forestation relationship; helpful expansion of computation and design data (Appendix B); and tools for measurement (Appendix C).

During the twenty-seven years of the career of the Illuminating Engineering Society's Committee on Street and Highway Lighting, the night use of public ways has grown greatly. Traffic has increased in speed and density. The studies by the Committee have established a substantial relationship between good fixed lighting and traffic safety. Understanding of the principles of good lighting, as reviewed in Appendix A hereof, has advanced. The following earlier publications of the Committee reflect the progress of the street and highway lighting technique through the years.

"Principles of Street Lighting"	1928
"Code of Street Lighting"	1930
"Code of Street Lighting"	1935
"Code of Highway Lighting"	1937
"Recommended Practice of Street Lighting"	1940
"Recommended Practice of Street and Highway Lighting"	1945
"American Standard Practice for Street and Highway Lighting" (Approved by American Standards Association)	1947

The present Practice has evolved out of these earlier documents, taking into account latest experience and modern equipment.

The Committee gratefully acknowledges the assistance rendered and data furnished by the Institute of Traffic Engineers and by the National Safety Council.

Suggestions for improvement based upon experience gained in the use of this standard will always be welcome and should be sent to the American Standards Association, 70 East 45th Street, New York 17, N. Y.

I.E.S. Committee on Street and Highway Lighting

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Preface

This preface is informative and not a part of the American Standard Practice for Street and Highway Lighting, D-12.2.

1. These recommendations have been prepared in furtherance of the Society's object, which is the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. Their purpose is to assist technicians and benefit the public.

2. The recommendations as to street and highway lighting that are contained herein call for fixed lighting of public roads, of a grade appropriate to modern requirements in the use of streets and highways. These recommendations have been equalled or exceeded in a large majority of the modernization programs since 1945. Where such lighting has been installed there has resulted a marked reduction in night accidents and expedited pedestrian and vehicular traffic. Its practicability and economy have been demonstrated. It is, however, in advance of much of street and highway lighting throughout the country. Because of this fact, it seems fitting that the Committee shall make known the basis of its recommendations.

3. The membership of this Committee is comprehensive as to points of view brought to bear on this subject. Those who represent state and municipal administrations join with representatives of manufacturers of equip-

*Approved by the Council of the Illuminating Engineering Society, August 1951. Final action by the American Standards Association for approval as an American Standard is pending.

ment and suppliers of electrical energy for its operation (both privately and publicly owned) and with others who are interested technically in the subject of lighting. These are convinced as to the need for these recommendations and as to the urgency of compliance with them.

4. In formulating these recommendations no item was included unless it received unanimous or virtually unanimous approval by the Committee. This procedure, though time-consuming, has assured that the completed recommendations represent a thoroughly studied consensus. As such they are approved unanimously by the Committee.

5. Nightfall brings increased hazards to users of streets and highways through limited visibility. Studies have shown that in normal times night traffic fatalities total about 10,000 to 12,000 per year over and above those that would be suffered if the night accident rate were as low as the daytime rate. The National Safety Council estimates that in 1950 about 19,200 were killed in traffic accidents at night, as compared with about 15,800 killed in the daytime. An approximation shown in the 1950 Accident Facts indicates that the motor vehicle death rate per billion vehicle miles is 14 at night compared with 5 during the day, almost three times as bad.

6. Widespread experience has demonstrated that under most circumstances prevailing in the United States it is practicable to light urban and suburban streets and the critical sections of highways so as to reduce very largely this terrible toll of lives that is attributable to lighting inadequacies. Furthermore, they feel that such improvements in the lighting of streets and highways generally are economically practicable. These preventive measures cost the community less than do the accidents caused by inadequate visibility.

7. Elimination of lighting inadequacies, to which so great a toll of life and limb must be attributed, is the immediately urgent element that underlies this American Standard Practice. It is evident, however, that the provision of lighting to improve traffic safety will contribute likewise to the reduction of crime and to the expeditious movement of traffic, which are two of the principal purposes of such lighting.

1. Classification of Streets and Highways

(a) An important factor, common to all street and highway safety considerations, is the volume of vehicular and pedestrian traffic. As traffic volume increases, traffic interference and exposure to accident also increases. Good visibility is more difficult to achieve in the confusion of moving vehicles and pedestrians, against which background the accident hazard must be discerned.

(b) The classification of vehicular traffic volumes shown in Table I is recommended by the Institute of Traffic Engineers.

(c) It is recommended that pedestrian street traffic be classified as shown in Table II.

TABLE I.—Classification of Vehicular Traffic.

Classification	Volume of Vehicular Traffic (Maximum Night Hour Both Directions)
Very light traffic	Under 150
Light traffic	150 — 500
Medium traffic	500 — 1200
Heavy traffic	1200 — 2400
Very heavy traffic	2400 — 4000
Heaviest traffic	Over 4000

TABLE II.—Classification of Pedestrian Traffic.

Classification	Pedestrian Volumes Crossing Vehicular Traffic Lanes
None	No pedestrians, as on express highways.
Light	As on streets in average residential districts.
Medium	As on secondary business streets.
Heavy	As on main business streets.

2. Classification of Luminaire Light Distributions

2.1—*Introduction*—(a) Proper distribution of the light from luminaires is one of the essential factors in efficient roadway lighting. The light emanating from the luminaires is directionally controlled and proportioned in accordance with the requirements for seeing and visibility described in Appendix A. Light distributions are generally designed for a typical range of conditions which include luminaire mounting height, transverse (overhang) location of the luminaires, longitudinal spacing of luminaires, widths of roadway to be effectively lighted, and percentage of lamp light directed toward the pavement and adjacent areas.

(b) Several methods have been devised for showing the light distribution pattern from a luminaire. The diagrams in Figs. 1 to 6 inclusive illustrate methods which are generally being used. The diagrams in Figs. 1 and 2 illustrate typical candlepower distribution curves in the vertical planes of maximum candlepower. Figs. 3 and 4 show the lateral candlepower distribution curve in the maximum cone. Other more complete methods of showing the light distribution from a luminaire are described in Appendix B; for example, Fig. 15.

(c) The diagrams in Figs. 1 to 4 inclusive show the distribution curves for a luminaire to be mounted at or near one side of the road. From the side location, the principal concentrations of light extend out toward the roadway in two distribution lobes as defined by the curves. Each lobe has a line of maximum candlepower which extends from the luminaire light center out through the point of maximum candlepower.

2.2—*Vertical Light Distributions*—(a) The maximum vertical planes, Figs. 1 and 2, include these lines of maximum candlepower. The vertical angle of maximum candlepower is measured in these vertical planes. It is the angle between the line of maximum candlepower and the vertical axis extending directly downward from the luminaire. This vertical angle of maximum candlepower and the vertical distribution curves in the maximum vertical planes are shown in the typical examples in Figs. 1 and 2.

(b) The upper diagram, Fig. 1, shows the usual method of presenting the luminaire distribution in the vertical planes of maximum candlepower. The candlepower curves to the right and left of this diagram are not necessarily opposite one another. This is merely the usual convenient method of presenting vertical distribution curves which may actually be in planes such as those shown in Fig. 2 when rotated back into the single plane of the paper. On curves such as Fig. 1, the lateral angles of the maximum vertical planes are specified.

The lateral angles at which the vertical planes extend out on the roadway are measured in the longitudinal plane as shown in Fig. 2 from the transverse roadway line extending directly across at 0 degrees with respect to a point on the roadway beneath the luminaire.

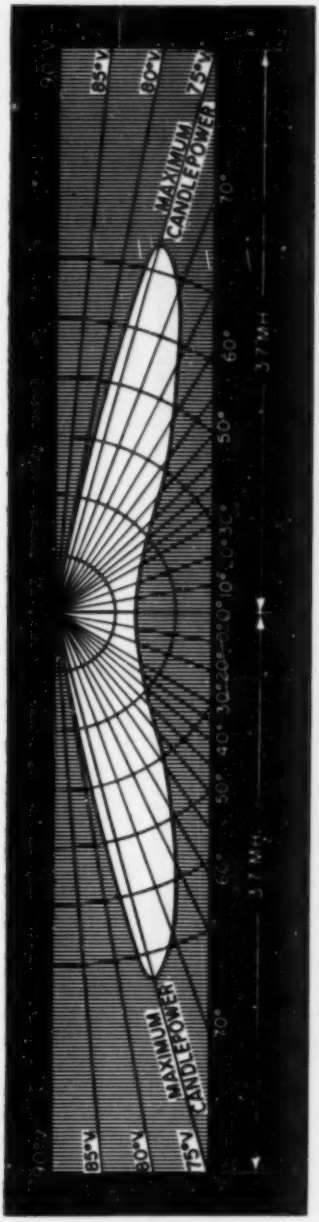


Figure 1. Candlepower curves showing an example of light distribution in vertical planes of maximum candlepower. The lateral angles of the vertical planes should be specified.

2.2.1—*Type I and Type II Vertical Distributions*—The vertical angles of maximum candlepower for typical Type I and Type II distributions range from 73 degrees to 80 degrees, as shown in Fig. 5.

2.2.2—*Type III, Type IV, and Type V Vertical Distributions*—The vertical angles of maximum candlepower for typical Type III, Type IV, and Type V distributions range from 70 degrees to 77 degrees, as shown in Fig. 5.

2.3—*Lateral Light Distributions*—(a) The lateral light distribution curves from a luminaire are customarily plotted on the surface of cones such as that in Fig. 3. The apex and vertical axis of the cone are the light center and vertical axis of the luminaire. A series of such cones may be used to plot curves showing the variation in lateral distribution at different vertical angles. When the conical surface includes the line of maximum candlepower, as it does in Figs. 3 and 4, this is the cone of maximum candlepower.

(b) The lateral angles of maximum candlepower in the cone shown in Fig. 3 are the same as the lateral angles at which the maximum vertical planes are shown in Fig. 2. The lateral angles of light distribution, such as that of maximum candlepower, are measured from the transverse line at 0 degrees with respect to the luminaire. These lateral angles of maximum candlepower usually vary with the lateral width of distribution. Both the angle of maximum candlepower and the width angle should be appropriate for the conditions to be met, such as roadway width and luminaire spacing.

2.3.1—*Lateral Width of Light Distributions*—**(a)** The angular lateral width of a light distribution is measured in the cone of maximum candlepower between the Reference line and the Width line as illustrated in Fig. 4. The line of maximum candlepower falls within this angular width of light distribution.

(b) The Reference line is either of the two radial lines formed on the surface of the cone of maximum candlepower where it is intersected by a vertical plane parallel to the curb and passing through the light center of the luminaire.

(c) The Width line is the radial line (the one which makes the larger angle with the Reference line) which passes through the point of one-half maximum candlepower on the lateral light distribution curve plotted on the surface of the cone of maximum candlepower.

(d) The lateral curves typical for luminaires for side-of-road mounting, Fig. 4, have half candlepower lines on one side of the distribution lobe which are nearly in line with or at a small angle with respect to the Reference line. There are some Type II, III and IV distributions found acceptable in which this line of one-half maximum candlepower does not reach the Reference line or in some cases extends beyond the Reference line. However, in general, it is preferable that there be no substantial departures. The lateral widths of light distributions have been classified in accordance with the following descriptions, as in Fig. 6.

2.3.2—*Type I—Lateral Distributions*—**(a)** *Type I* is a two-way lateral distribution having a preferred lateral width of 15 degrees in the cone of maximum candlepower on each side of the Reference line with an acceptable range of from 10 degrees to less than 20 degrees. The two principal light concentrations are in opposite directions along a roadway. The vertical plane of maximum candlepower is parallel with the curbline. The light distribution is similar on both sides of this vertical reference plane and is generally applicable to a luminaire location near the center of a roadway.

(b) *Four-way Type I* is a distribution having four principal concentrations at lateral angles of approximately 90 degrees to one another, each with a width range of 10 degrees to less than 20 degrees as described. This distribution is generally applicable to luminaires located over or near the center of a right-angle intersection.

2.3.3—*Type II—Lateral Distributions*—**(a)** Type II light distributions have a preferred lateral width of 25 degrees with an acceptable range of 20 degrees to less than 30 degrees. This distribution is generally applicable to luminaires located at or near the side of relatively narrow roadways. It is also used on wide roadways in opposite arrangements.

(b) *Four-way Type II* light distributions have four principal light concentrations, each with a width of 20 de-

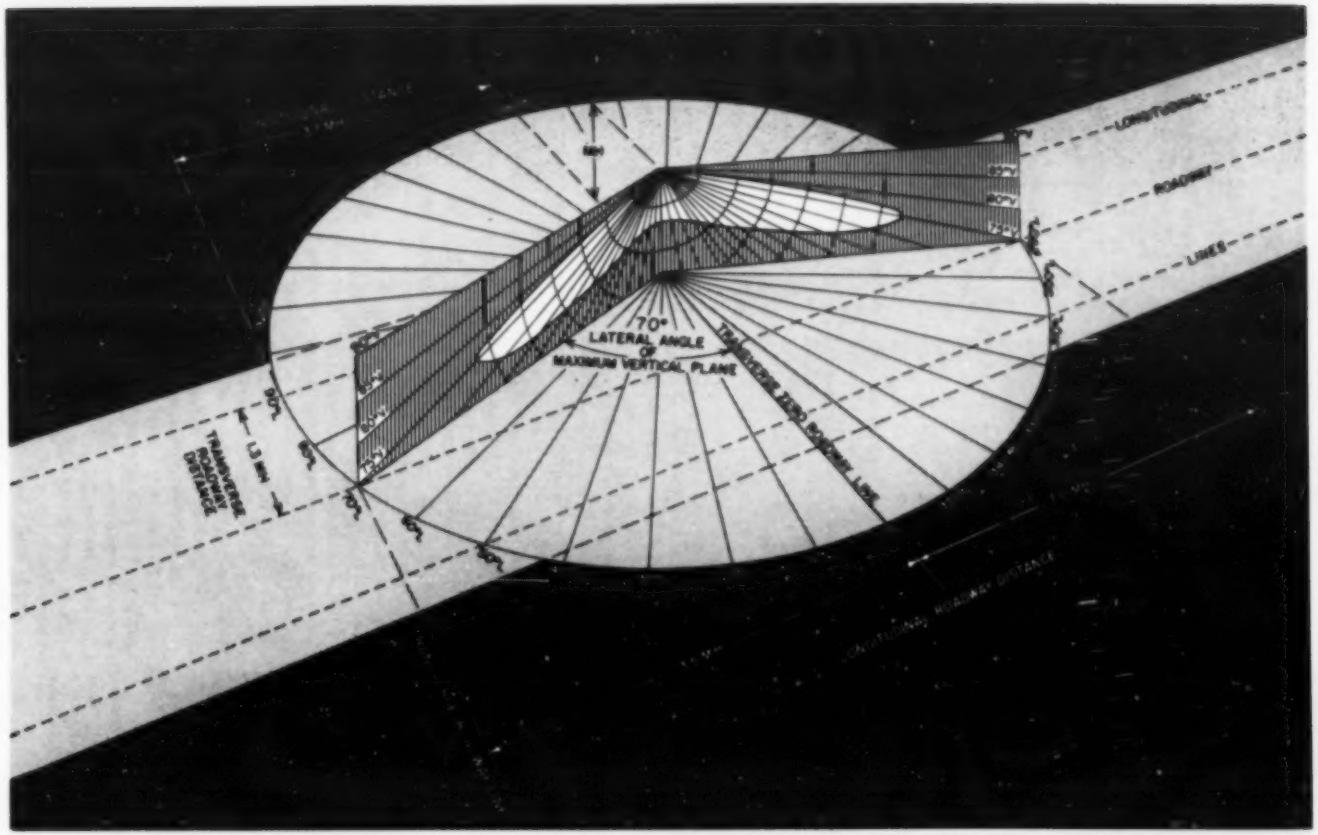


Figure 2. Vertical planes of maximum candlepower extending out on a roadway surface. This is one example of Type III light distributions.

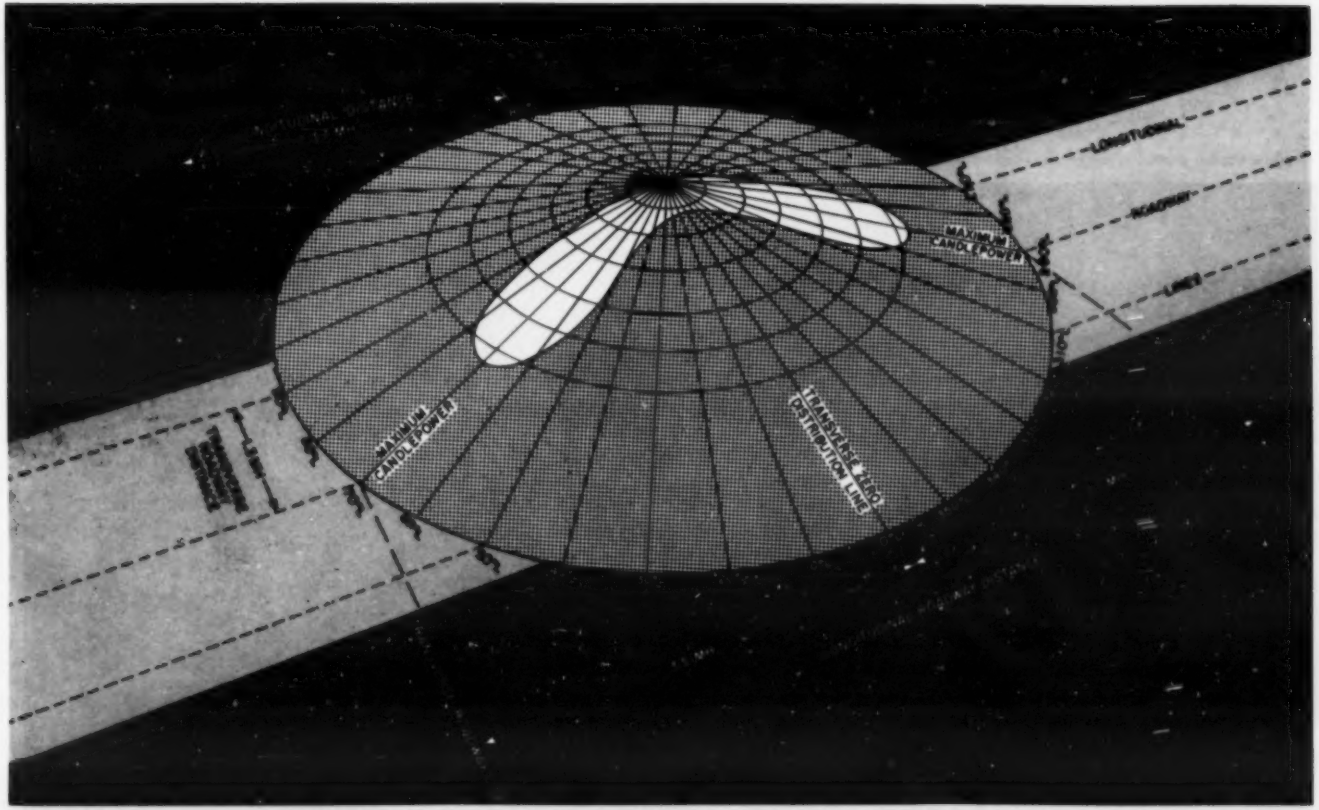


Figure 3. Lateral candlepower curves showing light distribution in cone of maximum candlepower. This diagram illustrates the designation of lateral angles such as maximum candlepower for one example of light distributions classified as Type III.

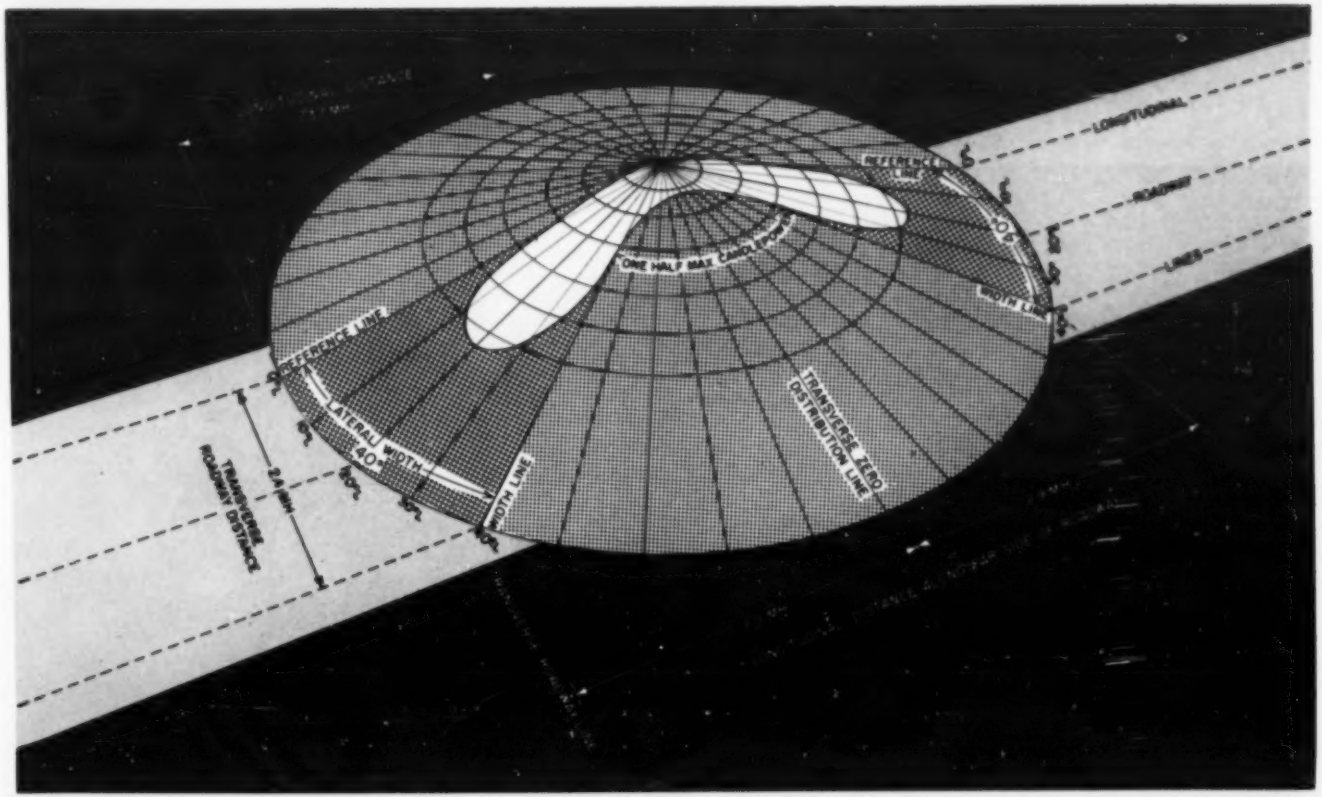


Figure 4. Measurement of lateral width of light distribution from the Reference Line in an example cone of maximum candlepower. This 40-degree lateral width is preferred for Type III lateral light distributions.

grees to less than 30 degrees as described. This distribution is generally applicable to luminaire locations near one corner of a right angle intersection.

2.3.4—*Type III Lateral Distributions*—The Type III light distributions have a preferred lateral width of 40 degrees with an acceptable range of 30 degrees to less than 50 degrees. This distribution is intended for luminaire mounting at or near the side of the roadway and is generally used for wider roadways than those for which the Type II is suitable.

2.3.5—*Type IV Lateral Distributions*—the Type IV light distributions have a preferred lateral width of 60 degrees with an acceptable range of 50 degrees or wider. This distribution is intended for side-of-road mounting and is generally used for roadway widths which are still wider than those for which the Type III distribution is suitable.

2.3.6—*Type V Lateral Distributions*—The Type V light distributions have a circular symmetry of candlepower which is essentially the same at all lateral angles. This distribution is intended for luminaire mounting at or near the center of a roadway, in the center islands of parkways, and at intersections.

2.4—***Variations and Comments***—**(a)** With the variations in street width, type of pavement surface, luminaire mounting heights, and spacing which may be found in actual practice, there could be a large number of "ideal" lateral distributions. This is obviously impractical. In the classification of lateral light distributions, certain ranges of pavement width have been chosen as typical. Ample light should be provided for the illumination of sidewalks and areas immediately adjacent thereto.

(b) Type I, II, III and IV lateral light distributions should vary in the cones at vertical angles other than the maximum cone in order to provide adequate coverage of the rectangular street area involved. The width of the lateral distribution required to adequately cover a typical width of roadway varies with the vertical angle of the cone in which the distribution is shown. In a cone at 77 degrees the lateral distribution for roadway coverage is narrower than that required in lower cones such as 73 degrees.

(c) Appendix B, particularly Fig. 16, may be referred to in selecting the desired width of light distribution to cover certain typical ranges of roadway width.

(d) For typical roadway conditions it is desirable to approximate rather closely the light distributions prescribed. Purposeful variations from these distributions are permissible under unusual conditions where such variations meet the seeing requirements more effectively. As an example of such purposeful variations, fluorescent lamp luminaires may offer effective distributions similar to Type I or II but broader than those described. Another example of variation is the use of Type IV and V luminaires in business districts where it may be desirable to direct more sideward and upward light to the building fronts, thereby lessening the brightness contrast along the street and increasing its general attractiveness.

3. Design of Street and Highway Lighting

3.1 — ***Introduction*** — **(a)** The many variables affecting street and highway lighting should be skillfully evaluated, including the economic and aesthetic aspects. These economic and aesthetic considerations are not within the scope of this Practice. The choice of light source, the extent to which available electric distribution facilities are used, and the type of poles, brackets and luminaires selected are all factors which will influence the overall cost of lighting. Any consideration of appearance will ultimately resolve into a matter of personal taste. However, elaborate or ornate design purely for the purpose of satisfying an aesthetic desire cannot be justified unless the basic requirements of good visibility have first been attained. It is important that roadway lighting be planned on the basis of traffic information, which includes the factors necessary to provide traffic safety.

(b) In addition, some of the factors applicable to the specific problem to be carefully evaluated are:

i. Traffic density
   a. Vehicular traffic volume
   b. Pedestrian traffic volume
ii. Traffic accident experience
   a. Vehicular traffic
   b. Pedestrian traffic
iii. Street crime experience
iv. Type, speed and turning movements of vehicles
v. Parking practices
vi. Roadway construction features
   a. Width of pavement or number of traffic lanes
   b. Character of pavement surface
   c. Grades and curves
   d. Location and width of curbs, sidewalks and shoulders
   e. Width and location of dividing and safety islands or channelizing curbs
   f. Intersections
   g. Traffic circles, clover-leaves and separations
   h. Bridges, viaducts, underpasses and overpasses
   i. Type and frequency of access locations

3.2—***Luminaire Mounting Heights***—**(a)** Table III presents mounting heights recommended for luminaires having light distributions of the types previously described. When practical, higher mounting may often be preferable. Even where structural problems are encountered, mounting heights more than a foot or so below those recommended cannot be considered good practice.

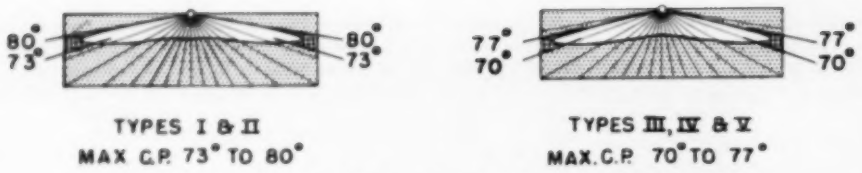
(b) Obstruction of light by foliage when luminaires are mounted at recommended heights is sometimes the occasion for adoption of lower mounting height. Judicious pruning of trees is usually a preferred alternative to mounting luminaires lower than recommended.

3.3—***Luminaire Spacing***—The spacing of luminaires is often influenced by the location of poles for trolley

TABLE III.—Luminaire Mounting Heights.

Approximate Lamp Size Lumens	Distribution Type			
	Type I	Type II	Type III	Types IV & V
2,500	25 ft.	20 ft.	20 ft.	20 ft.
4,000	25 ft.	25 ft.	25 ft.	25 ft.
6,000	25 ft.	25 ft.	25 ft.	25 ft.
10,000	——	25-30 ft.*	25-30 ft.*	25 ft.
15,000	——	30 ft.	25-30 ft.*	25-30 ft.*
20,000 - 25,000	——	30 ft.	30 ft.	25-30 ft.*

*The lower mountings are permissible on streets where the brightness contrast between the luminaires and their background is relatively low.



TYPES I & II
MAX C.P. 73° TO 80°

TYPES III, IV & V
MAX. C.P. 70° TO 77°

Figure 5. Recommended vertical light distributions in planes of maximum candlepower.

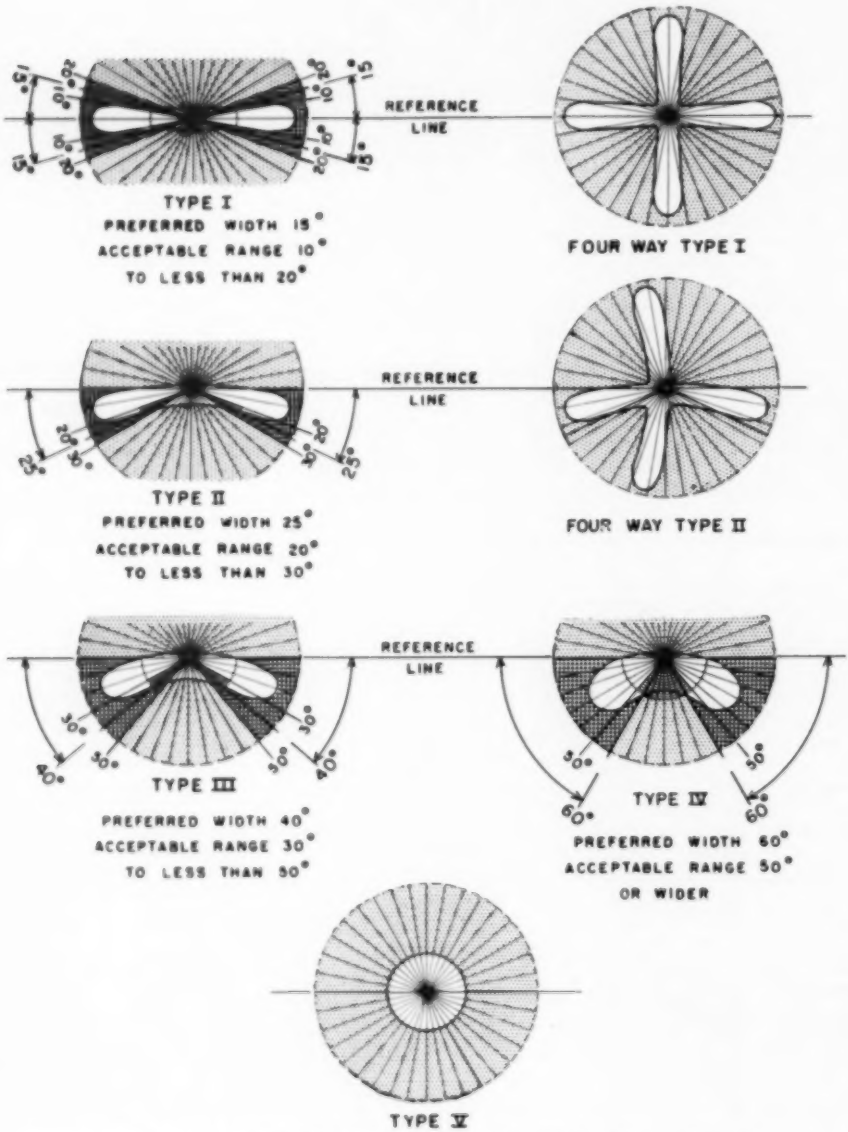


Figure 6. Recommended lateral light distributions in the cone of maximum candlepower.

attachments, electrical distribution poles, block lengths, and property lot lines. It is more economical practice to use larger lamps at reasonable spacings and higher mountings than to use smaller lamps at more frequent intervals with lower mountings. This is usually in the interest of good lighting *provided* the spacing-mounting height ratio is within the range of light distribution for which the luminaire is designed. This should maintain the desired ratio of lowest footcandles at any point on the pavement to average illumination. Terminology with respect to luminaire location and spacing is shown in Fig. 7. Fig. 16 may be useful as a guide with respect to the roadway coverage of a light distribution.

3.4 — *Transverse Location of Luminaires* — Luminaire distributions are most effective when suspended over the roadway pavement by suitable brackets, mast arms or other means. Type I luminaires are intended for mounting approximately over the center line of the roadway. Type II, III and IV luminaires are intended for mounting at or near the curbline. Generally such luminaires are mounted four feet or more out from the curb, depending upon the lateral light distribution and the type of roadway being lighted. Terminology regarding transverse location of luminaires is shown in Fig. 7.

3.5 — *Roadway Illumination* — Table IV shows the illumination recommended for roadways carrying the vehicular and pedestrian traffic volumes classified in Tables I and II. These footcandle values assume compliance with the recommendations on light distribution, mounting height, spacing and size of lamp.

3.6—*Typical Street Lighting Layouts* —Typical arrangement of luminaires for several roadway widths and footcandle levels are shown in Table V, Appendix B. Appendix B also pro-

TABLE IV.—Current Recommended Average Horizontal Footcandles (Lumens per Square Foot).

Pedestrian Traffic (Table II)	Vehicular Traffic Classification (Table I)			
	Very Light (Under 150)	Light (150-500)	Medium (500-1200)	Heavy to Heaviest (1200 up)
Heavy	*	0.8	1.0	1.2
Medium	*	0.6	0.8	1.0
Light or None**	0.2	0.4	0.6	0.8

*This condition is unusual, but if it should occur, the footcandle figures appearing in the column to the right may be used.

**Highways and expressways at grade should have illumination similar to that on urban streets with comparable traffic flow, either vehicular or pedestrian. An average of 0.6 footcandles is recommended for highways with full control of access as defined by the American Association of State Highway Officials, such as elevated or depressed expressways from which pedestrians are excluded. The values given for very light vehicular traffic pertain to roadways such as those in residential areas where vehicular speeds are low, of the order of 15 to 25 miles per hour.

In Using Table IV the Following Factors Must Be Considered:

1. The footcandle values in Table IV are current recommended practice for average illumination on the traffic-used pavement between curblines.

2. The lowest footcandle value at any point on the pavement should not be less than one-fourth the average value given in Table IV. The only exception to this requirement applies to roadways carrying very light vehicular traffic. On these roadways the lowest footcandle value at any point should not be less than one-tenth the average value in Table IV.

3. It is good practice to design a lighting installation with a "maintenance factor" so that the average illumination in service will not fall below the values in Table IV. Such maintenance factors make allowance for: (1) normal depreciation of lamps throughout life; and, (2) for loss of light due to accumulation of dirt on luminaires between cleanings. The rate and amount of depreciation will vary with local conditions and it is important that an adequate maintenance program be systematically carried out to minimize such light loss. Such a program should provide for operation of light sources at rated current or voltage, the regular replacement of depreciated lamps, and the periodic cleaning of luminaires.

4. Pavement brightness for the achievement of satisfactory visibility by silhouette discernment is dependent upon the light reflection characteristics of the pavement surface. The values in Table IV are based on favorable pavement reflectance of the order of 10 per cent. For the streets and traffic conditions in which silhouette discernment is important, due allowance must be made for pavement reflectances which vary from the favorable conditions assumed above. When reflectance is poor (of the order of 3 per cent), the illumination recommended should be increased 50 per cent. When reflectance is unusually high (20 per cent or more) the recommended values may be decreased 25 per cent. In general, these corrections will apply more specifically to streets carrying a light traffic volume where the illumination recommended is less than 0.8 footcandle. On streets carrying a heavy traffic volume and where 1.0 footcandle or more is recommended, visibility is more apt to depend on discernment by surface detail, and corrections for pavement reflectance become less important.

5. Visibility on sidewalks and roadside areas adjacent to the pavement should be given careful consideration when arranging and selecting luminaires. Usually lighting systems which provide the recommended illumination on the pavement also provide satisfactory illumination on adjacent areas.

6. Intersections require higher illumination than that recommended in Table IV for the approaching streets. The illumination at an intersection should be at least equal to the sum of the illumination values provided on the streets which form the intersection.

7. On some streets, such as those in business districts, it is often necessary to see the individual nature of objects which are projected against a background of moving traffic. On such streets a higher level of illumination and a high degree of uniformity are required as compared to conditions necessary for good silhouette discernment. Where seeing by silhouette is interrupted by conditions such as dense or turning traffic, lighting adequate for seeing objects by surface detail should be provided. Many installations provide average illumination exceeding the minimum recommended in Table IV, for reasons other than public safety. Such existing installations provide average illumination ranging up to 5 footcandles.

8. *The color of light* usually does not affect the level of illumination to be provided. Researches have shown that the visibility of objects on or near the roadway is substantially the same throughout the differences in color of light from sodium vapor, mercury-vapor, and filament lamps when the comparison is on the basis of equal amount of light and similar distribution.

vides a guide for calculation of illumination levels, a typical iso-footcandle diagram, a utilization curve, formulas and a typical computation for average footcandles, and the lowest footcandle value at any point on the pavement, an isocandle diagram, and a roadway coverage diagram.

4. Situations Requiring Special Consideration

The design data for roadway lighting contained in the preceding chapters may require modification to provide adequate visibility for certain special situations. While it is not possible to present precise recommendations for all special situations, the following paragraphs will assist the designer in exercising good judgment in solving some of the problems. These recommendations do not apply equally to all types of roadway lighting.

4.1 — *Forestation* — (a) Both street trees and street lighting are indispensable municipal assets. Through understanding and cooperation of those responsible, these street trees and street lighting need not conflict.

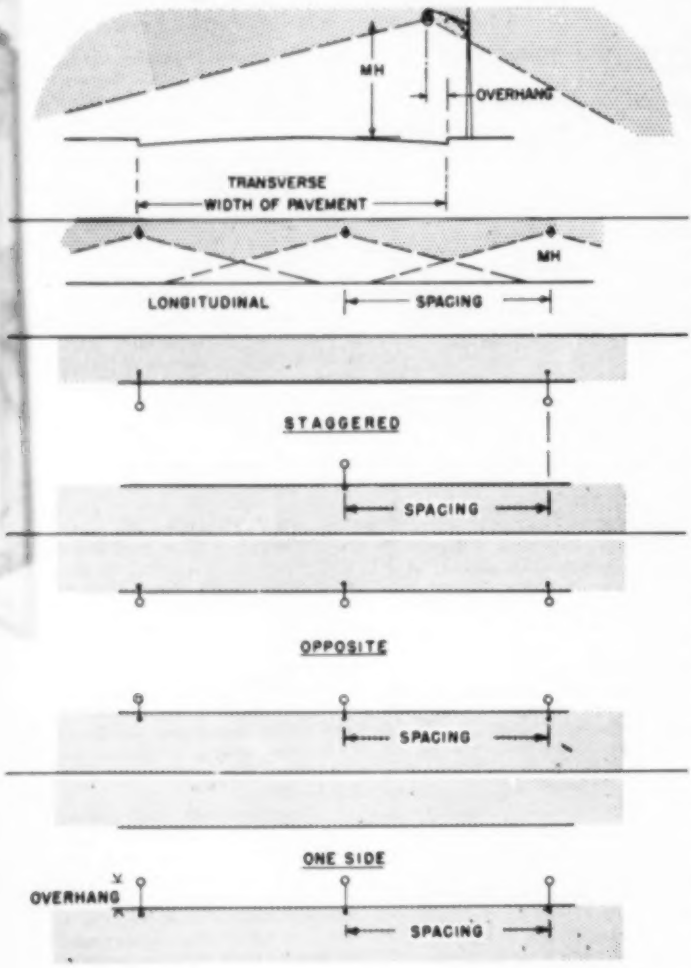


Figure 7. Terminology with respect to luminaire arrangement and spacing.

(b) Far-sighted arborists make selections based on trees which fit the street space available, soil condition, room available for root system, exposure and minimum conflict with utilities. Such selections may include upright, globular or ordinary tree shapes. Where conflicts exist between trees and street lighting, in most cases the answer is *proper* pruning. Where trees are too crowded, often the best remedy is removal of the conflicting tree.

(c) The presence of low overhanging foliage or shrubbery may seriously obstruct the light delivered to the pavement. Judicious pruning can reduce or eliminate the screening effect. There are instances where pruning increased the *average* street lighting effectiveness approximately one-third, and approximately doubled the lighting effectiveness in the critical areas of low visibility. It should be noted that even with high-mounted luminaires it is not necessary to prune all trees to the height of the luminaire. It is necessary to prune only those branches which fall below the cone of maximum candlepower. Such pruning when properly done is considered by arborists to enhance rather than detract from the appearance of the street as a whole. Fig. 8 illustrates the proper pruning for a typical lighting arrangement.

(d) Where pruning is not practicable, a modification of the lighting equipment and its application may be necessary. For example, luminaires may be mounted on longer mast arms or on span wire suspension over the center of the street, or, as a last resort, the mounting height may be reduced. Under this last condition luminaires having maximum candlepower at lower angles may be used with reduction in spacing and perhaps with proportionate reduction in lamp size.

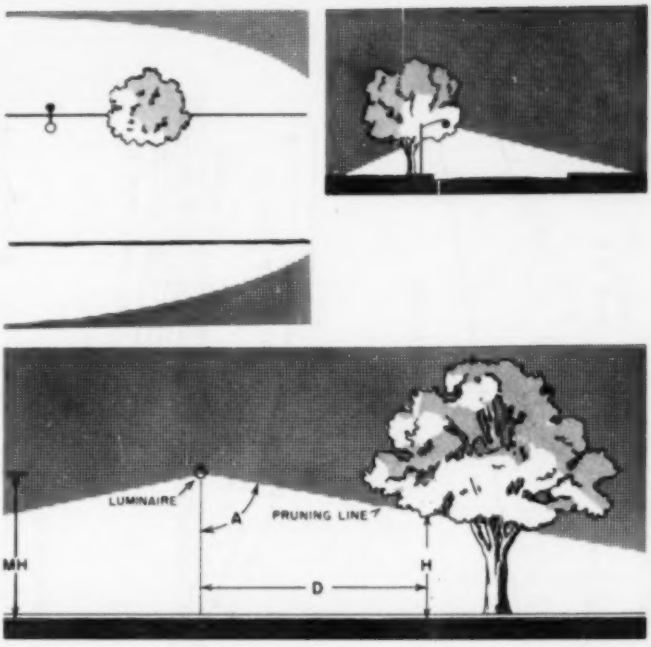
4.2—*Curves and Hills*—(a) Traffic hazards are usually greater on hills and curving roadways. The specular characteristics of the usual pavement surfaces require that the luminaires be more closely spaced than along adjacent straight sections. Luminaires must be placed on the outside of horizontal curves so that reflections between the luminaire and the eyes of an approaching driver are located on the pavement.

(b) On hills the problem is also one of effective continuity and overlapping of the pavement brightness areas from successive luminaires. Closer spacing is an aid in this respect. The diagrams in Fig. 9 show examples of recommended application of luminaires to horizontal curves of short radius, long radius, and hills. A diagram showing proper tilting of the luminaire with respect to a roadway on a hill is also shown in Fig. 9.

4.3—*Intersections*—(a) Intersections require more illumination due to the increased complexity of vehicular or pedestrian traffic. For the average, right angle, diagonal, "Y" or "T" intersection on urban streets the illumination should be at least equal to the sum of the illumination values recommended for the streets which form the intersection. For compound intersections, a detailed study of traffic flow, both pedestrian and vehicular, should be made. In all cases the luminaires should be located so that pedestrian crosswalks are illuminated effectively. Examples of luminaire locations for effective illumination of urban intersections are shown in Fig. 10.

(b) At a highway intersection the luminaires should be located so that specular pavement reflection areas best reveal the full roadway, its layout, signs, and pavement markings. Luminaires so located provide effective silhouette discernment of the presence and movement of vehicles and pedestrians. Wet pavement conditions greatly decrease the width of pavement reflection areas and must be considered in the location and selection of luminaires. Fig. 10 suggests a graduation of illumination at highway intersections, thereby enhancing visibility for vehicular traffic entering and leaving these areas.

4.4—*Railroad Grade Crossings*— Railroad grade crossings should be identified by adequate lighting. Driver attention and recognition of hazard may be as important as visibility of railroad cars. If the street or highway is unlighted, at least two luminaires with adequate size lamps are recommended, as shown in Fig. 10. These should be on opposite sides of the roadway and so located as to place the railroad crossing between a lighting unit and the vehicles approaching the crossing from both directions. The distance between luminaires and the outside track should not exceed 75 feet. Where the roadway is already lighted, the luminaires adjacent to the crossing should be located as described above, and the lamp should be at least one size larger than those employed on the remainder of the installation. Light of a cautionary color may be used.



LIGHT DISTRIBUTION VERTICAL ANGLE "A"	TREE PRUNING HEIGHT "H"
70°	MH—.36D
75°	MH—.26D
80°	MH—.17D

Figure 8. Recommended tree pruning to minimize conflict with roadway lighting.

4.5—*Alleys*—Alleys should be lighted to a degree sufficient for general protective and police purposes. Lighting should be provided at entrances, exits and intersections of public alleys. Unless traffic through such alleys is sufficient to justify lighting for traffic safety, the minimum recommended lighting is 1,000-lumen lamps on spacings not to exceed 200 feet.

4.6—*Bridges, Overpasses and Viaducts*—(a) The level of illumination for such structures should be not less than that recommended for streets or highways carrying an equivalent amount of traffic. When pedestrian walkways are so located that they cannot be lighted by the roadway units, additional lighting adequate for police and protective purposes should be provided.

(b) The approaches to bridges and overpasses, as well as viaducts, should receive particular attention, especially where there are changes in street or highway width, curb contour, or where abutments are so placed as to constitute a possible traffic hazard.

4.7—*Plazas and Traffic Circles*—The illumination of plazas or traffic circles should be at least equivalent to that recommended for streets or highways carrying the same volume of traffic and should be increased approximately 50 per cent if there is heavy pedestrian traffic or an unusual number of streets or highways enter-

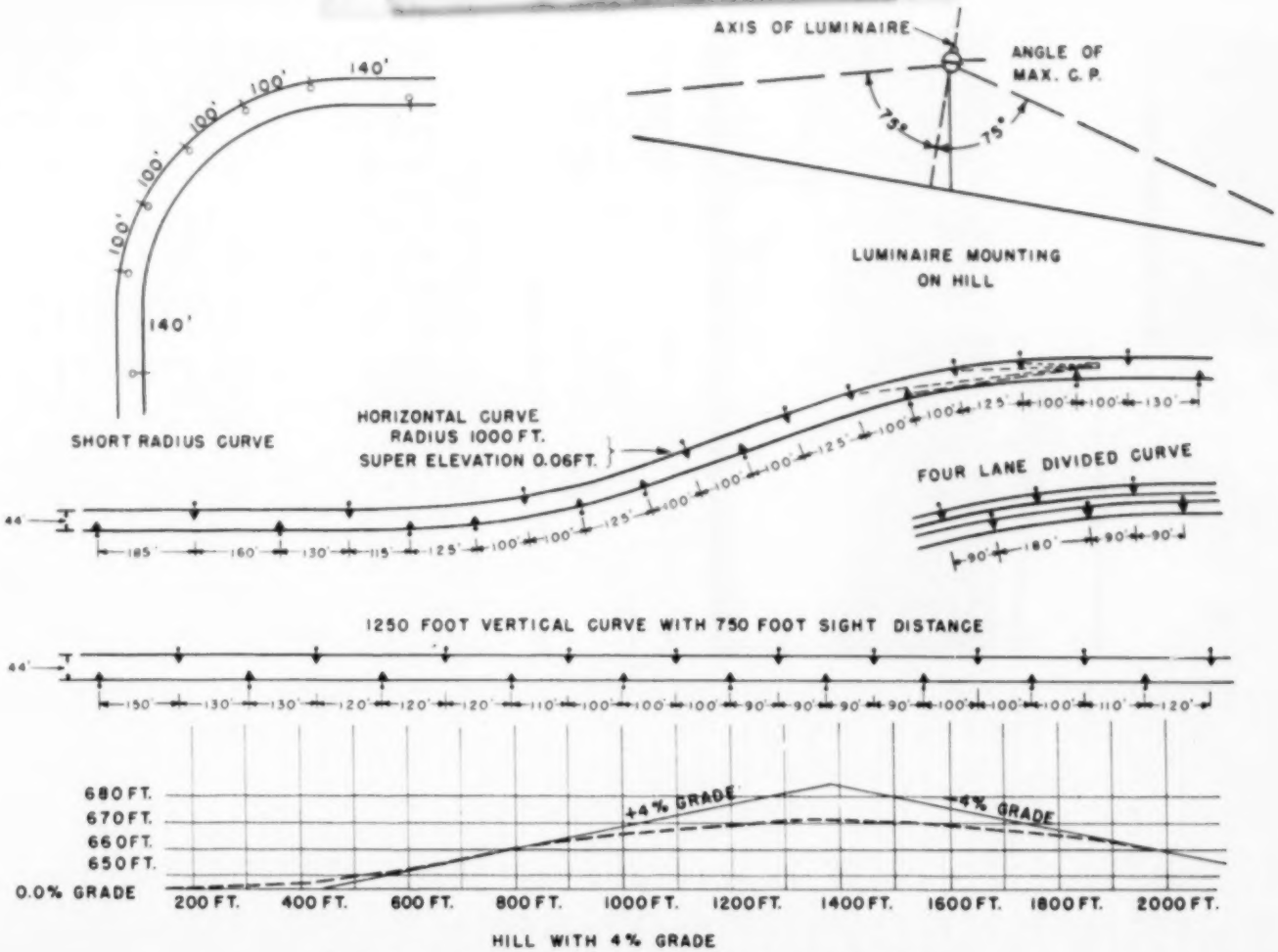


Figure 9. Layouts for curve and hill situations requiring special consideration.

ing the area. Lights should be placed to provide quick and easy identification of entrances and exits.

4.8—*Elevated or Depressed Roadways* — The illumination for elevated or depressed express roadways is as given in Table IV. However, such structures usually include special construction features to facilitate traffic flow and to provide means of entrance and exit. Lighting units should be properly located to identify dividing curbs, curves in roadways, or changes in width. Ramps for exit and entrance should have particular consideration as to lighting unit placement and may require somewhat greater illumination than the remainder of the roadway.

4.9—*Underpasses and Tunnels*—(a) When an underpass or tunnel is short (less than 100 feet in length) adequate illumination may be obtained from adjacent street lighting units on the approaches. However, long underpasses and tunnels require special treatment since lighting may be needed for both day and night. In general, the night illumination should be approximately 50 per cent greater than that recommended for the connecting street or highway, or for a roadway carrying the same volume of traffic. For day-time operation the entrances should have a supplementary lighting system. The purpose of supplementary lighting is to avoid an abrupt change between the several thousand footcandles of daylight and the few footcandles in the tunnel. Such an abrupt change temporarily reduces the motorist's ability to see, until his eyes have become adopted.

(c) In general, vehicular tunnels involve many special design features not common to streets and highways. For this reason, lighting by the conventional street lighting methods and equipment may not be satisfactory; and the services of an experienced street lighting engineer may be advisible in arriving at an effective solution.

4.10 — *Highway Interchange* — At a highway interchange special provisions should be made for the identification of roadways. Luminaires should be located so that they will aid the driver quickly in selecting the roadway to his destination, minimize chances for confusion, and make night use of such roadways more comfortable and convenient.

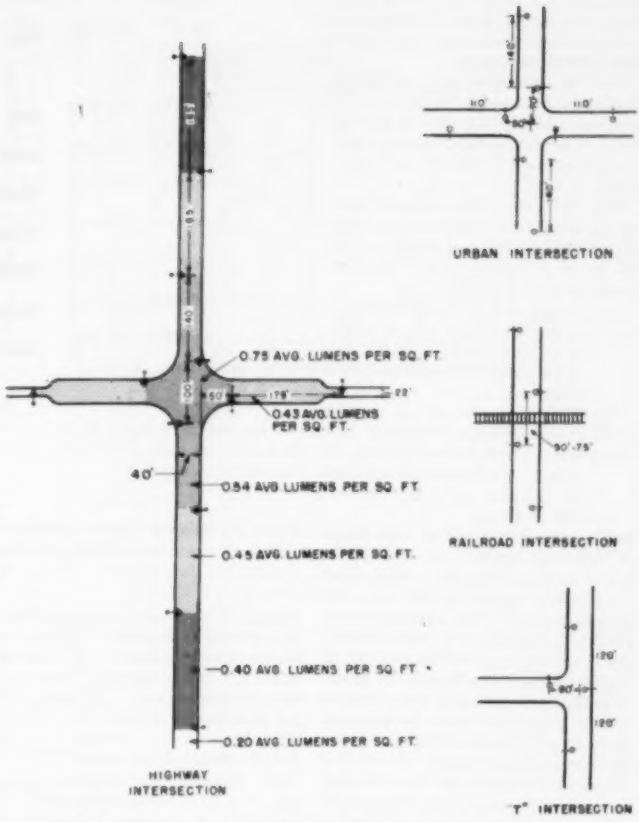

URBAN INTERSECTION
0.75 AVG. LUMENS PER SQ. FT.
0.43 AVG. LUMENS PER SQ. FT.
0.54 AVG LUMENS PER SQ. FT.
0.45 AVG. LUMENS PER SQ. FT.
0.40 AVG. LUMENS PER SQ. FT.
0.20 AVG. LUMENS PER SQ. FT.
HIGHWAY INTERSECTION
RAILROAD INTERSECTION
"T" INTERSECTION

Figure 10. Layouts for intersections requiring special considerations.

Appendix A—Fundamental Aspects of Roadway Lighting

This Appendix is not part of the "American Standard Practice for Street and Highway Lighting, D 12.2" but is presented as background material for the user of the standard.

A-1—*Purpose*—(a) The principal purpose of street and highway lighting is to produce quick, accurate, and comfortable seeing at night. These qualities of seeing combine to safeguard, facilitate, and encourage vehicular and pedestrian traffic. Where good seeing is provided, efficient night use is made of the large investment in street and highway construction and motor vehicles.

(b) *Seeing* has a broader meaning than visibility. It includes visual comfort and the alertness of the motorist or pedestrian, as well as visibility.

(c) *Visibility* as applied to night safety on streets and highways denotes the extent of detection or recognition of road details and objects by an observer possessing so-called normal vision and moving at legal speeds. As visibility is improved, alertness of motorists and pedestrians also tends to improve.

A-2—*Factors which Influence Seeing and Visibility*

A-2.1 — (a) *Silhouette Discernment* by brightness contrast. An object is discerned by silhouette when the brightness of all or a substantial part of the object is lower than the brightness of its background. This method of discernment predominates in the observation of distant objects on lighted streets and highways. The brightness of the pavement background is of major importance in the discernment of objects thereon. The pavement brightness necessary for adequate silhouette discernment is in itself desirable for the attainment of safe and comfortable driving conditions and the adjustment of the eye to its visual tasks.

(b) To enhance the brightness of the

pavement and uniformity thereof along and across the full width of the roadway is one of the principal objectives of street and highway illumination.

(c) The amount of light reflected or brightness of the pavement depends upon the intensity and angle of incident light from the luminaire and pavement specularity and reflectance at typical angles of view.

(d) The light reflecting characteristics of representative pavement surfaces, both wet and dry, have been measured. Among the important findings gained from these measurements are the following:

(1) A light tone of pavement surface contributes importantly to visibility of the pavement itself and also to discernment of obstacles by silhouette.

(2) When pavements are wet, or have a high specular component, visibility is enhanced by location of light sources several feet out over the pavement and along the outside of curves.

A-2.2—*Reverse Silhouette Discernment* by brightness contrast. At locations and under conditions when the brightness of a substantial portion of the object is greater than that of the immediate background, discernment is by reverse silhouette. This may apply to the visibility of objects at some locations on the roadway, usually to objects on areas adjacent thereto. Projections above the pavement surface, such as channelizing islands, abutments, and the upper portions of a pedestrian or vehicle are often discerned by reverse silhouette. Such discernment is enhanced by increasing the illumination and the reflectance of an object on sides facing toward the observer. Glint produced by the specular reflection of light sources on objects contributes to discernment.

A-2.3—*Recognition by Surface Detail* depends upon a high order of direct illumination on the sides of the object toward the driver. The object is then seen by variations in brightness or color over its surface without general contrast with a background. Under illumination provided for very heavy vehicular and pedestrian traffic, such as on streets in business districts, discernment by surface detail may predominate. The night legibility of traffic signs depends upon visual acuity and brightness of surface detail.

A-2.4—*Size of Objects* and identifying detail which must be recognized. Objects of significance in safety cover a wide range in size: a brick, a dog, a child, an adult, or a vehicle.

A-2.5—*Time Available* for recognition of an object or traffic situation. For the driver this time decreases with increase in vehicular speed. The time factor is involved to a greater extent and more time is needed for seeing as the level of illumination is decreased. The time involved for light adaptation of the eyes depends upon the range of brightness in the driver's field of view.

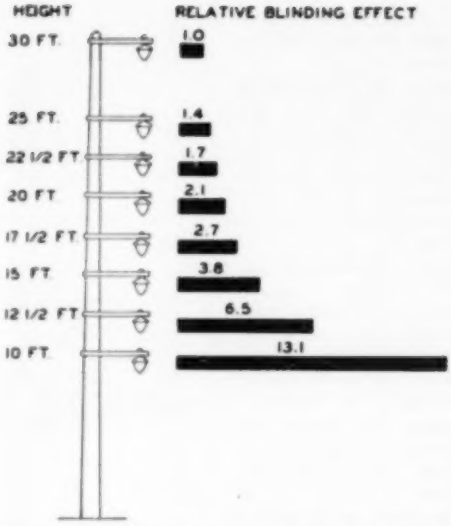


Figure 11. Relative blinding effect of glare from street lights at different mounting heights. Candlepower assumed constant.

A-2.6—*Glare*

A-2.6.1—*Disability or Veiling Glare* reduces visibility. The reduction depends upon the illumination produced at the eyes by the glare sources. It also depends upon the angles between the observer's line of vision along the roadway and the glare sources.

A-2.6.2—*Discomfort Glare* is diminished by reducing luminaire brightness or brightness contrasts. This may be accomplished through increasing the effective luminaire area and decreasing the intensity of light at "glare angles." In general, the most severe glare angles are those near the observer's line of sight.

A-2.6.3—*Measures to Reduce Glare*—(a) Disability and discomfort glare effects are decreased as the luminaires are moved out from the driver's normal line of sight or away from the center of the observer's field of vision. Modern practice in luminaire mounting height is an aid in this respect, as well as the restriction of light emanating from the luminaire at vertical and lateral angles where there is the most significant interference with driver visibility. Increasing the brightness of surroundings, such as the pavement and other areas forming a background in the field of view, reduces glare, improves visibility and the comfort of seeing.

(b) One representation of the effect of mounting height on glare is illustrated by Fig. 11. Such precautions as mounting the luminaires well above the pavement level in order to remove them from the visual axis are important in minimizing glare.

(c) It is also important that consideration be given toward minimizing the glare incidental to the improper use of automobile headlights. Where there is a continuous flow of vehicles, and particularly where pedestrians must cross the traffic stream, the *upper headlight beam presents a serious hazard.* In general, *the use of only the lower headlight beam is recommended where roadway lighting, adequate for traffic volume, has been provided.*

A-3—*Fundamental Design Objectives*—(a) Modern roadway lighting is designed to provide visibility for hundreds of feet ahead. The sight distances provided by such lighting reveal the contour and the alignment of the roadway for even greater distances. The lighted roadway serves as a background to minimize the effect of headlight glare and for judgment of speed and direction of vehicles. Consideration is given to factors of safety for average driver vision, concentration, attention, efficiency, fatigue, reaction and judgment.

(b) When designed for good seeing, the roadway lighting will encourage and increase the night use of streets and highways. This applies particularly to main inter-city arteries where it may aid

by distributing traffic loads to the night hours.

(c) The lighting design provides for safe vehicle operating speeds during the night hours. On lighted highways safe speeds may be fully ten to twenty miles per hour higher than on unlighted highways. The time saved due to differences in safe speeds is of considerable economic value.

(d) Lighting for good seeing is an important factor in the prevention of night accidents not directly attributable to mechanical failure or certain types of driver carelessness.

(e) Studies by the Bureau of Public Roads have shown that highway lighting encourages use of full roadway width and proper lanes, and acceptance of available passing opportunities.

Appendix B—Data on Luminaire Performance and Computation of Roadway Illumination

This Appendix is not a part of the "American Standard Practice for Street and Highway Lighting, D-12.2," but is presented as background material for the user of the standard.

The following information will be of value to those using the Standard Practice and is supplementary thereto. Additional data on luminaire performance is provided, as well as computation formulas and examples.

It is recommended that reference be made to the Illuminating Engineering Society "Guides to Testing Procedures," prepared by the I.E.S. Committee on Testing Procedures for Illumination Characteristics.

B-1—*Iso-footcandle Diagram*—(a) The illumination on a roadway surface produced by the light distribution from one or more luminaires may be shown by iso-footcandle diagrams. Figure 12 shows an example of an iso-footcandle diagram for a Type III luminaire.

(b) An iso-footcandle diagram is a graphical representation of points of equal illumination connected by a continuous line. These lines may show footcandle values on a horizontal plane from a single unit having a definite mounting height, or they may show a composite picture of the illumination from a number of sources arranged in any manner or at any mounting height. They are useful in the study of uniformity of the illumination and in the determination of the level of illumination at any specific point. In order to make these curves applicable to all conditions, they are computed for a given mounting height but horizontal distances are expressed in ratios of the actual distance to the mounting height. Correction factors for other mounting heights are usually given in the tabulation alongside the iso-footcandle curves.

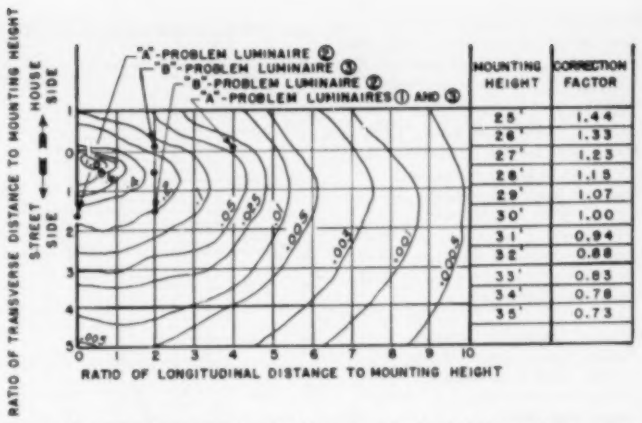


Figure 12. Example of isofootcandle diagram of horizontal footcandles on pavement surface for a luminaire providing a Type III light distribution; 10,000 initial lumen lamp, luminaire maintenance factor omitted.

B-2—*Utilization Curves*—(a) The utilization curves, available for various types of luminaires, afford a practical method for the determination of lumens per square foot (average footcandles) over the roadway surface where lamp size, mounting heights, width of paved area and spacing between luminaires are known or assumed. Conversely, the desired spacing or any other unknown factor may readily be determined if the other factors are given.

(b) Fig. 13 illustrates an example of a utilization curve of a Type III luminaire. The utilization curve indicates how much light falls on the roadway, but reveals nothing of the way in which this light is distributed. It must, therefore, be used in conjunction with the iso-footcandle diagram lines from the same luminaire in order to evaluate correctly the true performance of the luminaire, especially concerning uniformity or compliance with the recommended ratio of minimum illumination value to the average value.

B-3—*Formulas for Computations*—In the practical application use of the coefficient curves several formulas may be used. These are usually expressed as follows:

$$\text{Average Footcandles (Lumens per Sq. Ft.)} = \frac{(\text{Lamp Lumens})^{*} \times \left(\begin{matrix}\text{Coefficient of}\\ \text{Utilization}\end{matrix}\right) \times \left(\begin{matrix}\text{Luminaire Main-}\\ \text{tenance Factor}\end{matrix}\right)}{\left(\begin{matrix}\text{Spacing between Luminaires}\\ \text{in Feet}\end{matrix}\right)^{***} \times \left(\begin{matrix}\text{Width of Road-}\\ \text{way in Feet}\end{matrix}\right)} \quad (1)$$

Variations in this formula may be useful in solving for other unknowns:

$$\text{Spacing between Luminaires (in Feet)}^{***} = \frac{(\text{Lamp Lumens})^{*} \times \left(\begin{matrix}\text{Coefficient of}\\ \text{Utilization}\end{matrix}\right) \times \left(\begin{matrix}\text{Luminaire Main-}\\ \text{tenance Factor}\end{matrix}\right)^{**}}{\text{Average Footcandles} \times \text{Width of Roadway (Feet)}} \quad (2)$$

$$\text{Lamp Lumens}^{*} = \frac{\left(\begin{matrix}\text{Spacing between}\\ \text{Luminaires}\end{matrix}\right)^{***} \times \left(\begin{matrix}\text{Width of}\\ \text{Roadway}\end{matrix}\right) \times \left(\begin{matrix}\text{Average}\\ \text{Footcandles}\end{matrix}\right)}{\left(\begin{matrix}\text{Coefficient of}\\ \text{Utilization}\end{matrix}\right) \times \left(\begin{matrix}\text{Luminaire Maintenance}\\ \text{Factor}\end{matrix}\right)^{**}} \quad (3)$$

*Lamp Lumens used in the above formulas may be:
(a) Initial lamp lumen rating, if answer is desired in terms of initial illumination.
(b) Mean lamp lumen rating, if answer is desired in terms of average illumination during rated life of the lamp.
(c) Lamp lumen rating at 70 per cent of rated life, if the answer is desired in terms of the illumination after the lamps have operated for a time corresponding to 70 per cent of their rated life. When group lamp replacements are made at 70 per cent of rated lamp life this lumen value is generally representative of the minimum light output.

**Use of luminaire maintenance factor is good practice, as described in Note 3 pertaining to Table IV. In the following problems it is assumed that conditions warrant the use of a luminaire maintenance factor of 80 per cent.

***This is the longitudinal distance between luminaires if spaced in staggered or one-side arrangement. This distance is one-half the longitudinal distance between luminaires if luminaires are arranged in opposite spacing. See Fig. 7.

B 4—*Typical Computations* — To illustrate the use of the iso-footcandle diagram, Fig. 12, and utilization curves, Fig. 13, a typical calculation is provided as follows:

Given: A traffic street having light vehicular traffic and light pedestrian traffic, with layout as shown in Fig. 14.

Staggered luminaire spacing	120 ft
Roadway width curb to curb (pavement)	50 ft
Luminaire mounting height	30 ft
Luminaire overhang	5 ft
Luminaire maintenance factor	80% = (0.8)
Filament lamp (20 ampere series, 10,000 lumen initial rating, 3,000 hour rated average laboratory life) mean lamp lumens	9250

Required:

A. To calculate the lumens per square foot (average footcandles) for the above road pavement.

B. To determine the lowest footcandle value at any point on the pavement (which should be not less than one-fourth the average footcandles).

B 4.1—*For Average Illumination* — **(a)** Determine the coefficient of utilization for the "street side" of the luminaire:

Ratio (street side) (from Fig. 14) $\frac{50'-5'}{30'} = \frac{45'}{30'} = 1.50$

Coefficient of utilization from Fig. 13 for ratio 1.50 is 0.385.

(b) To determine "house side" coefficient of utilization:

Ratio (house side) (from Figure 14) $\frac{5'}{30'} = 0.16$

Coefficient of utilization from Fig. 13 for ratio 0.16 ..... 0.02

(c) Total coefficient for "street side" plus "house side" is 0.405

(d) To determine average illumination on roadway use formula (1) from paragraph B 3, Formulas for Computation, giving:

$$\text{Average Footcandles (Lumens per Sq. Ft.)} = \frac{9250 \times 0.405 \times 0.8}{120 \times 50} = 0.5 \text{ footcandle}$$

B 4.2—*Lowest Footcandle Value at Any Point on the Pavement*—**(a)** In the foregoing example the calculations indicate that a spacing of 120 feet will provide an average horizontal illumination value of 0.5 footcandle. As specified in factor No. 2 under Table IV: "The lowest footcandle value at any point on the pavement should not be less than one-fourth the average." With a layout as assumed in Fig. 14, points A, B and C indicate positions on the street where the illumination may be lowest.

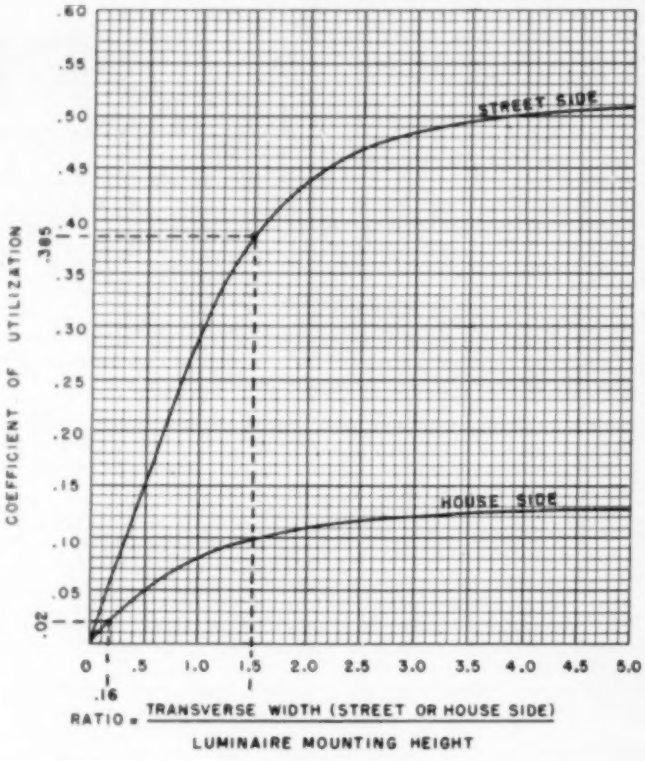


Figure 13. Example of coefficient of utilization curves for a luminaire providing a Type III light distribution.

(b) The following procedure may be used to determine the illumination which each luminaire contributes to a point. For example, at point A on the pavement only the three adjacent luminaires are contributing significantly to the illumination.

(c) The location of the point A with respect to a point on the pavement directly under the luminaire is dimensioned in transverse and longitudinal multiples of the mounting height. Assuming that the luminaire distribution provides iso-footcandle lines (horizontal footcandles) as shown in Fig. 12, point A is then located on this iso-footcandle diagram for its position with respect to each luminaire.

(d) To determine the contribution of each luminaire to point A.

Luminaires No. 1 and No. 3

Locate Point A—Transverse 5 feet to house side:

$\frac{5}{30} = 0.16$ times mounting height

Longitudinal 120 feet along pavement

$\frac{120}{30} = 4.0$ times mounting height

At point A for these luminaires the estimated footcandle value from Fig. 12, iso-footcandle diagram, is 0.04 footcandle. This is from each luminaire, No. 1 and No. 3. Both luminaires provide 0.08 footcandle.

Luminaire No. 2

Locate Point A—Transverse 45 feet to side street

$\frac{45}{30} = 1.5$ times mounting height

Longitudinal location is 0, directly across from the luminaire.

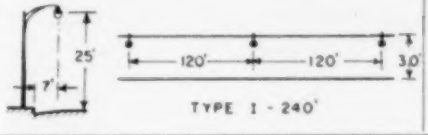
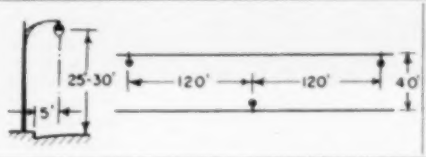
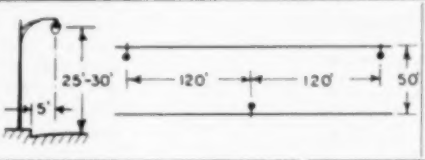
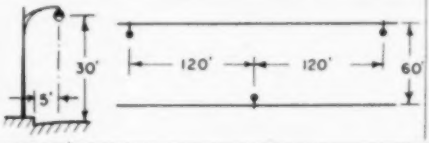
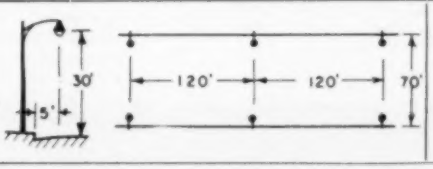
At point A for this luminaire the estimated footcandle value from Fig. 12 is 0.3 footcandle.

(e) The total at point A from the three luminaires is 0.08 plus 0.3 = 0.38 footcandle.

(f) Correction factors are then ap-

TABLE V.—Typical Street Lighting Layouts.

Based on initial lamp lumens and a maintenance factor of 80 per cent.

		DIST TYPE	LAMP SIZE	SPACING	** AVG FT-C
VERY LIGHT TRAFFIC LIGHT PEDESTRIAN		I	6,000L FILAMENT	240' ONE SIDE	0.2
		II	2,500L FILAMENT	120' ONE SIDE	0.2
LIGHT TRAFFIC LIGHT-TO-MEDIUM PEDESTRIAN		III	6,000L FILAMENT	120' STAGGERED	0.4
		III	10,000L FILAMENT	120' STAGGERED	0.7
MEDIUM TRAFFIC MED PEDESTRIAN		III	15,000L FILAMENT 15,000L * MERCURY	120' STAGGERED	0.8
HEAVY TRAFFIC MED PEDESTRIAN		III	20,000L * MERCURY	120' STAGGERED	1.0
HEAVIEST TRAFFIC HEAVY PEDESTRIAN		III	20,000L * MERCURY	120' OPPOSITE	1.8
		IV	25,000L FILAMENT	120' OPPOSITE	1.5

*A-H1 and E-H1 mercury lamps are rated 15,000 and 20,000 lumens respectively, in vertical operation. Lumens are slightly lower in horizontal operation.

**The footcandle values are based on a pavement having a reflectance of 10 per cent. When reflectance is poor (of the order of 3 per cent) the average footcandle level should be increased 50 per cent. When reflectance is unusually high (20 per cent or more) the recommended values may be decreased by 25 per cent.

plied to this photometric data from Fig. 12 as follows:

i. Iso-footcandle data such as that given in Figure 12 is subject to the tabulated correction for mounting height. In this problem with 30-foot mounting height the correction factor is 1.

ii. Since the data is based upon initial 10,000 lumens from the lamp in the luminaire instead of 9250 mean lamp lumens, the footcandle values should be multiplied by 9250/10000 = 0.925.

iii. Also, the problem is based on a luminaire maintenance factor of 0.8, which also should be applied to footcandle data taken from Fig. 12.

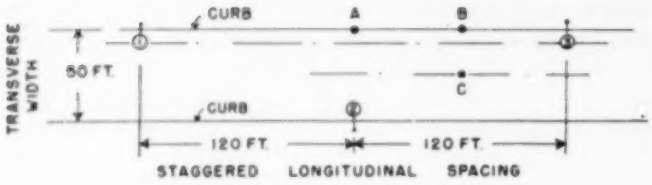
Therefore:

Illumination at Point A under assumed conditions = (Initial footcandles × correction factor for mounting height × lamp lumen factor × luminaire depreciation factor) = 0.38 × 1.0 × 0.925 × 0.8 = 0.28 footcandle.

This value of 0.28 footcandle is more than one-fourth the average of 0.5 footcandle. The illumination at point A is therefore in accordance with Standard Practice.

(g) Similar calculations for points B and C will show that the footcandle values at these points also are greater than 0.15 footcandle (one-fourth of the 0.5 average).

(h) Although the points A, B and C are generally considered good check locations, the pavement illumination at any point may be checked in this manner. If the check shows that the illumination at any point falls below one-fourth of the



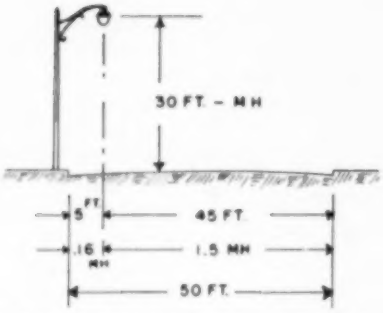


Figure 14. Layout of luminaires and roadway assumed for typical computation.

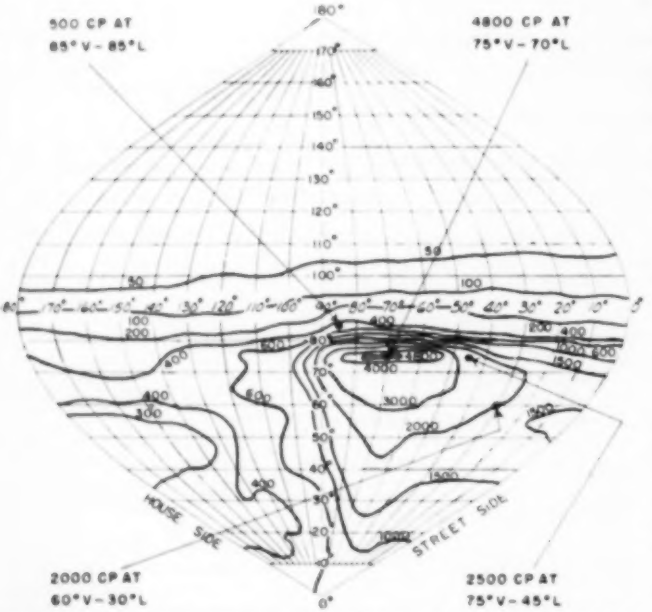


Figure 15. Example of isocandle diagram method for showing the light distribution from a luminaire. The distribution classification is Type III.

average, it is an indication that a modification in one or more of the contributory factors is necessary for a satisfactory solution to the problem.

B-4.3—*Higher Average Horizontal Footcandles*—**(a)** In the foregoing problem the 0.5 footcandle illumination is more than that called for by current recommended practice (Table IV) when vehicular and pedestrian traffic is classified as Light (Table I, Table II).

(b) If it is desired that the lighting be designed for higher traffic volumes, larger size lamps may be used in the luminaires or the spacing between luminaires may be decreased. The latter involves an increase in the number of lighting units per mile of roadway. Refer to "Luminaire Spacing," Section 3.3.

B-5—***Typical Street Lighting Layouts***—A few examples of lighting layouts are shown in Table V. This table is based upon initial lamp lumens and indicated luminaire light distributions. The foregoing calculations and recommendations should be used in determining the proper solution for a given set of conditions.

B-6—***Isocandle Diagram of Luminaire Light Distributions*** — **(a)** Isocandle diagrams, such as illustrated in Fig. 15, show the manner in which the light output from a luminaire is directionally proportioned and controlled at various vertical and lateral angles. Such a diagram provides more complete photometric data on candlepower distribution than that obtainable from curves shown in Figs. 1 to 4 inclusive. The light distribution is plotted in lines of equal candlepower on a special web representing the surface of a sphere with the luminaire at the center. At the bottom of the diagram 0 degrees vertical is directly beneath the luminaire. On the right hand side of the diagram is 0 degrees lateral. Vertical and lateral angles are numbered the same as those in Figs. 1 and 2. The hemisphere, 0 degrees to 180 degrees lateral, is usually sufficient to show a candlepower distribution when the curves 180 degrees to 360 degrees are similar. The arcuate web lines extending from the top to the bottom of the diagram may be considered as corresponding to a series of vertical planes at the designated lateral angles. The horizontal web lines correspond to cones at the designated vertical angles.

(b) The data obtained from the isocandle diagram is essential for engineering appraisal of factors which effectively contribute to visibility and seeing. For example, candlepower incident to various portions of a pavement reflecting characteristics, will yield data regarding pavement brightness. Such a diagram also shows the reduction and control of can-

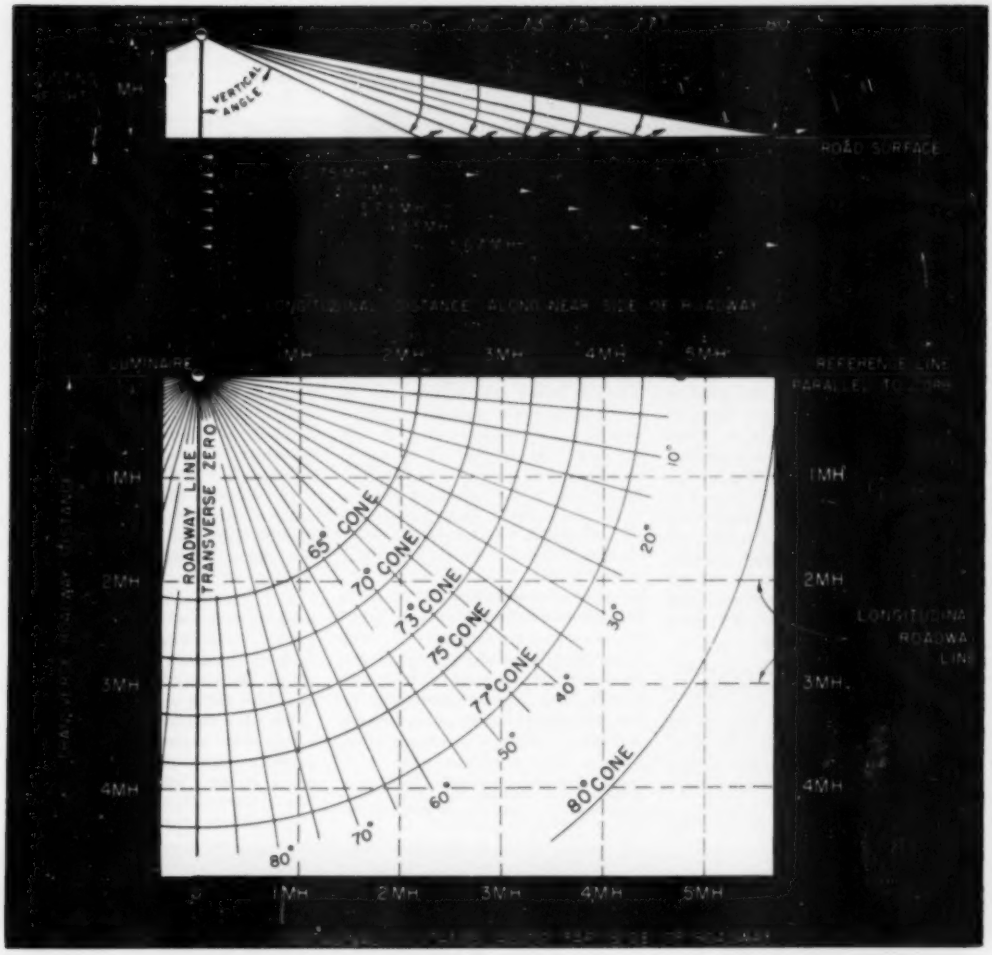


Figure 16. Roadway coverage for lateral widths of light distribution as measured from the Reference Lines in cones having several different vertical angles.

dlepower at glare angles. As an aid to interpretation the candlepower is indicated by arrows at certain vertical and lateral angles of light distribution.

B-7—*Roadway Coverage*— (a) The roadway coverage provided by a luminaire light distribution may be estimated by reference to the diagrams in Fig. 16. The upper vertical section diagram shows the distance at which certain vertical angles intersect the road surface. These distances, in relation to mounting height, are measured along the pavement surface from a point thereon which is directly beneath the luminaire.

(b) In the lower diagram, presenting a top view of the roadway, these distances are represented by circular lines. The circular lines show where the cones at designated vertical angles intersect the pavement surface.

(c) The radial lines in the lower diagram shown as emanating from the luminaire designate lateral angles of eight distribution widths. These lateral width angles are measured from the *Reference Line* parallel with the curb as explained in Section 2.

(d) Longitudinal and transverse roadway lines are laid out on the pavement surface in dash-lines forming squares. The side of each square represents a distance equal to the luminaire mounting height. Longitudinal distances are measured along the roadway from the transverse line extending across from a point beneath the luminaire. Transverse distances are measured across the roadway from a line on the pavement directly beneath the Reference Line.

(e) A point on the roadway corresponding to a lateral width angle of 40 degrees in the 75-degree cone is at the longitudinal distance of 2.9 MH measured along the far side of the roadway.

Figure 17. Low range footcandle meter.

The transverse distance to this point is 2.4 MH. These distances are shown in the perspective diagram, Fig. 4. Other situations of lateral width in a specified cone may be estimated from Fig. 16.

(f) The longitudinal and transverse roadway coverage varies considerably with the vertical angle of the cone and the lateral width angle. For example, Table VI presents the lateral width angles of light distribution in several cones which cover approximately the same transverse roadway coverage.

Appendix C—Measurement of Factors in Roadway Lighting

This Appendix is not a part of the "American Standard Practice for Street and Highway Lighting, D 12.2," but is presented as background material for the user of the standard.

Illumination, and some of the other factors in seeing and visibility, may be measured by several methods. *It is recommended that the applicable I.E.S. testing guides* be referred to in making investigations of street lighting illumination.* These guides have been prepared by the Committee on Testing Procedures for Illumination Characteristics and are available from the Illuminating Engineering Society.

C-1—*Illumination Meters*—(a) Accurate measurements of illumination on lighted streets involve two principal problems. First, street illumination levels are relatively low, as compared with interior lighting levels for which most light meters are designed. Hence, it is necessary to limit the choice of meters to those which have satisfactory accuracy in the range of street illumination — from a minimum of 0.02 up to 5 footcandles. Measurements must be taken with special care to minimize errors. At most locations the light comes at large angles of incidence to the street surface. It is essential, therefore, that the instrument employed be of a substantially "cosine corrected" type and that it be leveled accurately for each reading.

(b) A third source of difficulty exists where streets are lighted with vapor illuminants—sodium or mercury—because of the color of the light. If a direct-reading type of meter is used it must be "color corrected," or the scale values must be multiplied by a proper constant applying to the meter and the illuminant in question. If visual photometry is employed, the photometric observer should be skilled in the use of the photometer.

(c) A low-range, high-sensitivity footcandle meter, shown in Fig. 17, is now available for street lighting measurement. It has a self-leveling, cosine-corrected, photo-voltaic cell as primary detector. There are two scales, 0-1 and

TABLE VI.

If Lateral Width in 75° Cone Is:	Approximate Lateral Width of Distribution in Other Cones For Equivalent Transverse Roadway Coverage Is:			
	77° Cone	73° Cone	70° Cone	65° Cone
25°	21°	29°	35°	47°
30°	26°	35°	43°	60°
35°	30°	41°	51°	86°
40°	34°	47°	61°	—
45°	38°	54°	74°	—
50°	41°	61°	—	—

*"Guide for Outdoor Illumination Tests," ILLUMINATING ENGINEERING, Vol. XLVI, No. 8 (August 1951); "Report on Photoelectric Photometers" now being prepared.

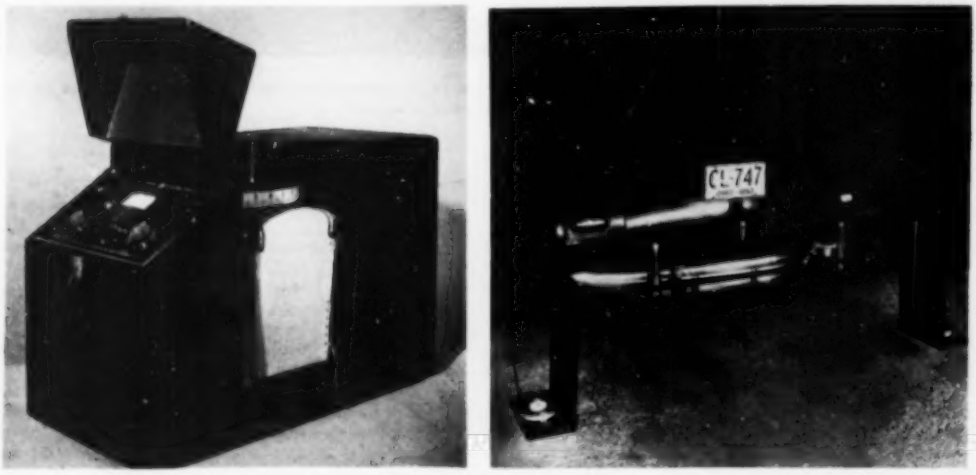


Figure 18. Taylor-Pracejus illumination recorder: (a) amplifier and graphic recorder, (b) two photocells on automobile.

0·5 footcandles. Readings are indicated on an illuminated meter face.

(d) The Macbeth Illuminometer has been widely used for street lighting measurements. A white test plate of diffuse texture and known reflectance is supplied with the instrument. This plate is accurately leveled at a test station, shielded from any extraneous light, and the brightness of the plate measured with the Illuminometer by a photometrist. The angle at which the test plate is viewed should not be greater than 30 degrees from the vertical.

(e) The Taylor-Pracejus Illumination Recorder consists of an amplifier, graphic recorder, color- and cosine-corrected photocells — all mounted on an automobile. This is shown in Fig. 18. The instrument makes a tape recording of the point-by-point variations in footcandle levels as the car is driven along a lighted roadway.

(f) The Luckiesh-Taylor Brightness Meter shown in Fig. 19 may be used to measure street illumination in a manner similar to that for the Macbeth Illuminometer. This meter may also be used to measure pavement brightness at near grazing angles of view by using horizontally the narrow slit through the comparison field.

C-2—*Evaluation of Roadway Lighting*— The "Street Lighting Evaluator," Fig. 20, is used for field measurements of the three principal factors in seeing on lighted streets. These are pavement brightness, obstacle brightness and veiling glare. The Evaluator has three parts—the pavement bed, the glare integrator, and the instrument box—electrically connected to the battery of the automobile. By means of a calculator, the measurements of pavement brightness, obstacle brightness and glare are combined. The end result is expressed in two ways. One is an Evaluator Rating which represents relative effectiveness of the lighting system. The other is the classification of street for which the illumination is adequate under the American Standard Practice.

Figure 19. Luckiesh-Taylor brightness meter.

C-3—*Field Measurement of Pavement Reflectance*—(a) A simple device, Fig. 21, may be used for measurement of approximate reflectance of pavements. The measurements are made by day, preferably with an overcast sky. The pyramidal box, black inside, is supported by three "legs" about a foot above the pavement. A light meter is placed, cell downward, over the aperture in the top of the pyramidal box. The light meter is read. Then a piece of cardboard, whose reflectance has been measured in the laboratory, is placed on the pavement below the box. The light meter is again read. The product of the ratio of the (meter reading for pavement/meter reading for cardboard) × reflectance factor of cardboard = approximate pavement reflectance. Readings may be made at several points on a pavement to approach an average value.

(b) It is to be noted that such a measurement of reflectance does not differentiate between the specular and diffuse components, both of which are present in traffic-worn pavements.

Figure 20. Street lighting evaluator.

Figure 21. Device for field measurement of pavement reflectance.

C4—*Field Measurement of Pavement Illumination* — **(a)** When field tests are made to determine the footcandle illumination with the point-by-point method, it is recommended that a layout of test stations as shown in Figs. 22, 23 and 24 be used. These layouts are those recommended in the "I.E.S. Guide for Outdoor Illumination Tests" as published in ILLUMINATING ENGINEERING, August, 1951.

(b) In making outdoor illumination tests as previously suggested, it is recommended that the test plate be leveled at not more than 6 inches above the roadway surface and that the test plate be compensated for departure from cosine law. It is also recommended that data regarding the installation conditions include the following:

Average of reading stations _____ Street classification _____

Minimum value _____ Type of pavement _____

Maximum value _____ Reflectance _____ (optional)

Ratio of minimum to average _____ Luminaire type _____

Ratio of Maximum to average _____ Light source _____

Electrical and operating conditions _____

Mounting height _____ Spacing _____ Environment _____

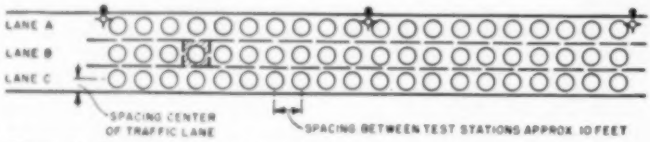


Figure 22. Test stations with street luminaires on one side of roadway. Crosshatching indicates typical rectangular test area at center of which illumination reading is taken.

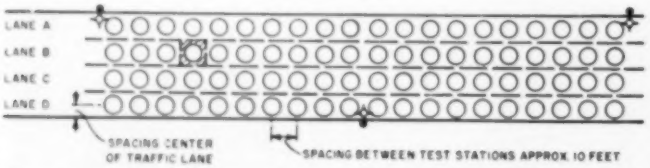


Figure 23. Test stations with luminaires on both sides of roadway in staggered arrangement. Crosshatching indicates typical rectangular area at the center of which illumination reading is taken.

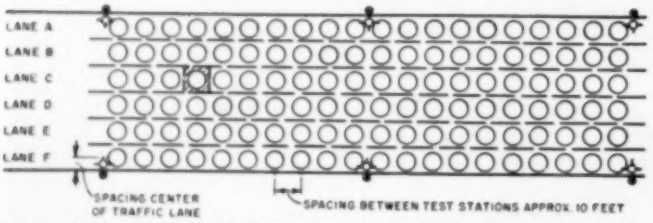


Figure 24. Test stations with luminaires on both sides of roadway in opposite arrangement. Crosshatching indicates typical rectangular area at the center of which illumination reading is taken.

APPENDIX D — GLOSSARY OF TERMS USED IN STREET AND HIGHWAY LIGHTING

Absorption Factor — the ratio of the light flux absorbed by an object to the flux incident upon it.

Bracket or mast arm—an attachment to a lamp post or pole from which a luminaire or lighting fixture is suspended.

Brightness—may be expressed in footlamberts or candles per square inch. (See Footlambert.)

Candle—the unit of luminous intensity. At a distance of one foot, a candle produces an illumination of one footcandle (equivalent to one lumen per square foot) upon a surface normal to the beam.

Candlepower—is luminous intensity expressed in candles.

Efficiency of a Source—the ratio of the total luminous flux to the total power input. In the case of an electric lamp it is expressed in lumens per watt.

Footcandle—one lumen per square foot, the unit of illumination. It is the unit used in expressing the illumination received upon a surface from all light sources, both directly and by reflection.

Footlambert—the brightness of a surface (as observed from a given direction) which, if it has the same brightness in all directions, would reflect or emit one lumen per square foot. The brightness of any reflecting surface in footlamberts is the product of the illumination in footcandles by the reflection factor of the surface at the particular angle of observation.

Lamp—the light source employed.

Lamp Post—a standard support provided with necessary internal attachments for wiring and external attachments for bracket and luminaire.

Lateral Width of a Light Distribution —the lateral angle between the Reference Line and the Width Line measured in the cone of maximum candlepower. This angular width includes the line of maximum candlepower.

Lighting Unit—the assembly of pole or post with bracket and luminaire.

Lumen — the unit of luminous flux in terms of which the output of a light source is expressed.

Luminaire—a complete lighting device consisting of a light source together with its direct appurtenances, such as globe, reflector, refractor, housing and such support as is integral with the housing. The pole, post or bracket is not considered a part of the luminaire.

Mast Arm—see Bracket.

Mounting Height (MH) — the vertical distance between the roadway surface and the center of the light source in the luminaire.

Pole—a standard support generally used where overhead lighting distribution circuits are employed.

Reference Line—either of the two radial lines where the surface of the cone of maximum candlepower is intersected by a vertical plane parallel to the curb line and passing through the light center of the luminaire.

Reflection Factor (Reflectance) — the ratio of the light reflected by a surface to the light incident upon it.

Spacing—the distance in feet between the successive lighting units, measured along the center line of a street.

Width Line—the radial line (the one which makes the larger angle with the Reference line) which passes through the point of one-half maximum candlepower on the lateral light distribution curve plotted on the surface of the cone of maximum candlepower.

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TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Northwestern Regional Conference Held at Resort Hotel, Swampscott, Mass.

The neighborhood of the Northeastern Regional Conference—Swampscott, Mass,. and the large attendance to it—tempts a comparison with the first national I.E.S. convention, also held near there. In point of fact, a whole editorial could be written on the growth in size and importance of all regional meetings within the past few years. They have become local conventions of considerable value to the profession and the industry.

Registration for the two-day (June 19-20) meeting in Swampscott exceeded 350. Not too long ago, a group of this size would be good attendance for a national convention, and in Boston at the first I.E.S. meeting, 200 registered members and guests was a big convention.

More important, however, was the heavy attendance at the technical sessions, themselves of convention calibre. Standing room only obtained at each session. Discussion was well organized.

The meeting was held at the Hotel Preston, a beautiful resort hotel right on the ocean's edge. A taste of high life at the seashore was an enjoyable respite from more serious business.

Technical Sessions

The conference was under the direction of Regional V-P Richard G. Slauer, and Conference Chairman R. B. Brown, Jr., with Section officers serving as session chairmen. The program was:

Thursday Morning — June 19

Chairman, F. Vorlander, New England Section Chairman

Opening Address—R. B. Brown, Conference Chairman.
"A Report to the Region"—R. G. Slauer, Regional V-P.
"Comparison of Methods for Computing Interior Illumination"—C. L. Crouch, Technical Director, I.E.S., New York.
"Some Observations on Fundamentals in Street Lighting Design"—A. W. Fowle.

Thursday Afternoon — June 19

Chairman, E. Salter, New York Section Chairman

"A Study of Eye Complaints from Fluorescent Sources"—W. Allphin.
"Latest Developments in Mercury Lighting"—W. S. Till.
"My Most Interesting Lighting Installation" Contest.

PEN and pencil set is presented to Pres. S. G. Hibben (right) to express appreciation of Northeastern Region. V-P Richard G. Slauer presented the gift for the Region.

Friday Morning — June 20

Chairman, C. W. McCormick, Connecticut Section Chairman

"Grid Systems, A Trend in School and Office Lighting"—E. H. Church.
"Some Limitations of School Lighting Practices"—R. L. Biesele, Jr.
"Is Daylight Practical in New England Schools?"—Louis J. Drakos, Architect.

Friday Afternoon — June 20

Chairman, H. Klopot, Program Chairman New England Section

"Dynamic Color Systems—Electronically Controlled"—R. G. Williams.
"Quality in Industrial Lighting"—Lawrence S. Cooke.
"Protective Lighting in Industry"—J. S. Lindsay.
"Lighting for Hazardous Locations"—K. A. Sawin.

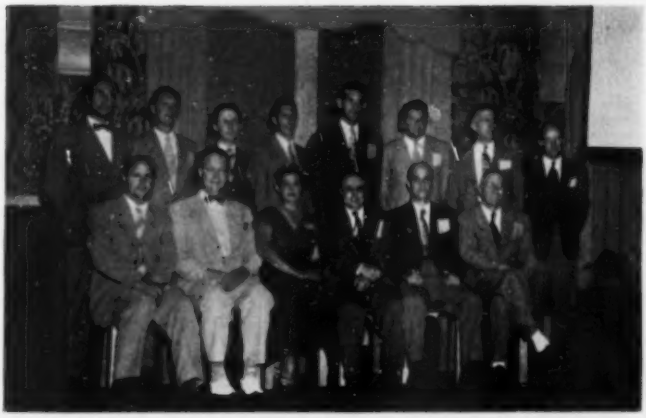
Entertainment

In addition to the entertainment afforded by Nature herself, American history, and the New England seacoast, planned entertainment offered by the conference committee added still further to the resort enjoyment of this meeting. The Ladies Reception Committee, with Mrs. George Almy directing, conducted tours for visiting ladies through Old Salem, picturesque Marblehead, and lovely old New England homes, card parties, brunch get togethers, etc.

Highlight of all the fun was the Pres-

SEEN at the Northeastern Regional Conference: R. B. Brown, Jr., Boston, A. W. Fowle, Newark, Ohio, L. B. Cooke, Boston, S. G. Hibben, I.E.S. President, and C. L. Crouch, I.E.S. Technical Director.

ident's Banquet June 19, followed by dancing. And best of all, was the skit put on at the Banquet—"The Life of Samuel Higgens (Hibben)." Format of the piece was re-enactment of "important moments" through his life. The affectionate though side-splitting script was read by Racie Finney, Westinghouse, Boston, who took the part of an interviewer, and Dick Wilson, G. E., Boston, as "Mr. Higgens." Demonstrated with slides of President Hibben's actual boyhood photographs, "Higgens'" life unrolled from birth, through school, college and first job—so funny it would have to be seen to be appreciated. None laughed harder than the butt of all this, himself. Gifts to President Hibben included a lifetime supply of feathers, the same quantity of plastic lily picks, and three circlines linked together, for which he is to design a luminaire. The Conference Committee, no less generously, presented him with a fine pen and pencil set.



NORTHEASTERN Regional Conference Committee. Hard-working chairmen contributing to the success of the meeting are: seated, F. J. Vorlander, H. B. Finney, Mrs. Geo. Almy, R. B. Brown, Jr., T. S. Williams, J. W. Young. Standing, D. T. Carter, W. B. Kennedy, H. C. Mayer, H. A. Klopot, C. M. Morse, C. W. McCormick, E. H. Salter, R. O. Mills.

My Most Interesting Lighting Job

The Regional Contest for "My Most Interesting Lighting Job" featured the first place winners of the local contests previously conducted by New York, New England and Connecticut Sections.

First prize winner was H. Neil McIntyre, General Electric Co., Lynn, Mass. (New England Section) whose job was a most unique fluorescent floodlighting installation at Logan Airport. Mr. McIntyre will represent the Region at the Finals in Chicago.

Second place was won by R. Gillespie Williams, Color Lighting Corp., North Bergen, N. J. (New York Section) with his spectacular lobby of light (see May 1952 IE, p. 251).

Third place was Edward R. Cole, Hartford Electric Light Co. (Connecticut Section). Mr. Cole's job was a fine remodeling installation at the State Savings Bank, Hartford, Conn.

Ideas Worth Stealing

Northeastern Region used many organizational devices for a smooth running conference. Two of their ideas, however, are so worthwhile they could well be made the practice for all I.E.S. meetings.

One was a portable "headquarters display." Property of the New England Section, this case exhibits all I.E.S. publications and furnishes order blanks for forwarding requests to headquarters. Since the Society's publications are, in the final analysis, the sum total of its work, this service to members was especially noteworthy.

Another good iden was the Sustaining Members display. A prominent lobby wall was given over to an exhibit which pointed up the benefits of I.E.S. through the support of Sustaining Members.

Under a list of the Region's Sustaining Members, were placards demonstrating I.E.S. Service to the industry:

1. Use of increased quantity of high quality light.
2. Aids for increasing knowledge of personnel.
3. Open forums for exchange of ideas and techniques.
4. Publications, Handbook, data sheets and Conference papers.
5. Research to find answers.
6. Evaluation of Lighting to its rightful place among other arts and sciences.
7. An increasing supply of young engineers through Student Branches.

The end result of all this was shown as:

(a) Rapid growth of the lighting industry.
(b) Sale of light as estimated by the 1950-1951 Committee on Progress.
(c) Trillion lumen-hours forecast for the period 1950-2245.
(d) Saturation point not in sight.

REGIONAL V-P R. G. Slauer (white dinner jacket) congratulates R. G. Williams (right) and presents check for winning installation in Regional contest for "My Most Interesting Lighting Installation." Pres. and Mrs. Hibben are at left in the picture.

Who's Who

The many people responsible for the seemingly effortless manner in which the Northeastern Regional Conference was conducted were:

Regional Officers:
R. G. Slauer, Regional Vice-President
C. W. McCormick, Chairman, Connecticut Section
F. J. Vorlander, Chairman, New England Section

INTERMISSION at Northeastern Regional Conference, Swampscott, Mass., brings together (l. to r.) H. B. Finney, New England Section Secretary-elect; C. W. McCormick, Conn. Section Chairman; Francis Clark, Chairman-elect; and R. W. Harris, Hartford, Conn.

Conference Executive Committee:
R. B. Brown, Jr., Chairman
Committee includes chairman of all subcommittees as listed below.

Finance Committee:
J. W. Young, Chairman
A. H. Brooks — W. B. Elmer
E. R. Cole — R. L. Smart

Papers Committee:
H. A. Klopst, Chairman
W. B. Kennedy — R. O. Mills
M. D. Kimball — E. J. Perkins
G. G. Rae

Hotel Committee:
T. S. Williams, Chairman
J. R. Cornell, Jr. — C. M. Holden
Norman Falk — P. H. Lamson
Monroe Taylor

Attendance & Registration Committee:
H. B. Finney, Chairman
J. F. Canning
H. W. Chapman
W. H. Garrett
R. M. Harris
A. L. Lambert
R. W. Wilson

News Publicity Committee:
D. T. Carter, Chairman
H. C. Mayer

Ladies Reception Committee:
Louise H. Almy (Mrs. George B.), Chairman
Mildred C. Halvorson (Mrs. Cromwell A. B.)
Grace Raddin (Mrs. Ellery H.)
Alice Rex (Mrs. Charles H.)
Mildred Slauer (Mrs. Richard)
Marjorie Smart (Mrs. Raymond L.)
Catherine Vorlander (Mrs. Fred J.)
Janet Finney (Mrs. Horace)

Entertainment Committee:
R. W. Wilson, Chairman
S. L. Baker — R. C. Finn
H. W. Chapman — H. J. Wilson

Decorations & Exhibits:
C. M. Morse, Chairman
L. E. Innis
R. L. Smart

PRESENTATION of Charter to officers of new Eastern New York Chapter. L. to r., R. G. Slauer, Regional V-P, Clarence Peck, C. E. Waldron, the Chapter's first Chairman, R. White, Don Voorhies, James Jennings and Matthew Vitartas.

Summary of Action At June Council Meeting

The June meeting of Council, last full Council of this Administration, was postponed from its normal date till June 19, to be scheduled concurrent with the Northeastern Regional Conference in Swampscott, Mass., June 19-20. The meeting was held at the Hotel Preston, with the following attendance: S. G. Hibben, President, presiding; Past Presidents, C. H. Goddard and Walter Sturrock; Vice-Presidents, A. H. Manwaring and E. M. Strong; General Secretary, C. C. Keller; Directors, G. W. Beals, R. L. Biesele, Jr., W. P. Lowell proxy for L. A. Hobbs, D. M. Jones, R. B. Brown, Jr. proxy for R. A. Palmer, and J. S. Schuchert; Regional Vice-Presidents, P. H. Hildebrand, F. P. Labey, C. N. Laupp, R. G. Slauer, F. C. Winkler; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; C. E. Ellis, Advertising and Promotion Manager; and J. Daniels, E. C. Huerkamp, L. B. Paist, M. N. Waterman.

Membership

On recommendation from E. M. Fahey, Chairman of the Board of Examiners, action was taken to approve the election of 15 Members, transfer of 12 Associates to Member grade, 156 Associates, and 7 Students. Membership totals to date were reported as follows:

September 30, 1951		June 18, 1952
7166	Total Membership	7750
32	Members Emeritus	33*
42	Fellows	43
1709	Members	1812
5174	Associate Members	5577
209	Student Members	285

*Includes 10 Fellows.

Technical Progress

An interim report on the technical work of the Society during the past year was given by Prof. E. M. Strong, President-Elect, and C. L. Crouch, Technical Director. Mention was made of the meeting held in Syracuse at the start of this year's work, calling together chairmen of technical committees for full discussion and organization. Progress reports were given on the work of a number of technical committees, indicating early completion of several recommended practices, particularly for supplementary lighting, foundries, and textile mills. Attention was called to the work of the Light Sources Committee who have developed a series of Questions and Answers

(*Continued on page* 11A)

Installations To See When You Are in Chicago

Class of Job	Installation	Address	Interesting Features
Office & Drafting Room	Stimsonite Plastics	3445 N. Kimball Ave.	Luminous ceiling, concealed sprinkler system, acoustical baffle
Hotel	Apartment & Hotel Management	837 W. Wilson Ave.	Luminous ceiling
Lobby	Commonwealth Edison Co.	72 W. Adams St.	Recessed troffers
Statue	Alexander Hamilton Memorial	Diversey, Lincoln Park W. & Lakeview Ave.	Statue lighting
Sports	Joliet Memorial Stadium	2 miles West of Joliet, Illinois on Troy Road	Stadium lighting
Showroom	Pullman-Standard Car Mfg.	79 E. Adams St.	Large area louverall ceiling with recessed supplementary lighting
Hotel Lobby	Morrison Hotel	79 W. Madison St.	
Cocktail Lounge & Restaurant	Sherman Hotel	N. Clark & W. Randolph	Black light murals, edge lighting
Industrial	Chicago Offset Printing Co.	610 W. Van Buren Ave.	
Industrial	Laboratory of S. C. Johnson Co.	Racine, Wisconsin	Explosion proof units
Industrial	Bell & Howell Co.	7100 McCormick Blvd. Lincoln, Illinois	Provided for continuous rows of industrial RLM fixtures
Office	Kraft Food Company	505 & 601 Sacramento	Continuous glass paneled fluorescent troffers
Office	First Federal Savings & Loan Association	Waukegan, Illinois	Recessed fluorescent, incandescent downlighting, cold cathode valance
Office	Bell Savings & Loan Association	79 W. Monroe St.	Cove lighting, recessed fluorescent
Office	Consulting & Group Study Room	Neuro-Psychiatric Hospital	Luminous ceiling, high footcandle level, remotely mounted ballasts
Store	Wolock & Bauer Shoes	4 N. Michigan Ave.	
Store	Fell's Department Store	595 Central Ave. Highland Park, Ill.	
School	Hinsdale Township High School	Hinsdale, Illinois	Acoustical material used in conjunction with lighting system
School	Immanuel Lutheran School	Westchester, Ill.	Ceiling mounted, louvered fluorescent lighting
Beauty Salon	Arnold Field's Beauty Salon	2247 E. 71st St.	Luminous ceiling, acoustical baffle
Club	Elks Club	Logans Park, Indiana	Edgelighted carved plastic panel
Stage	Kungsholm Restaurant	100 E. Ontario	Puppet stage lighting
Lobby	All State Insurance Bldg.	3245 W. Arthington	Surface mounted, continuous fluorescent pattern
Mail Box	La Salle Towers Hotel	1211 N. La Salle St.	Lighted mail indicator
Artist's Studio	Robert Dickens Studio	908 W. Ernst St.	Surface mounted incandescent lighting for wall illumination
Store	Hillman Super Mart	1615 N. Harlem Ave.	Louvered fluorescent, recessed incandescent
Industrial	Studebaker	South Bend, Indiana	Continuous rows of louvered fluorescent lighting
Cocktail Lounge	Henrici's Mart Room	Merchandise Mart	Black light mural, recessed glass bottom troffers. Pin hole spot lights
Bank	First National Bank	Clark & Monroe	Incandescent downlighting
Church	Sinai Temple	5350 South Shore Drive	Fluorescent coves and incandescent downlights
Cosmetic Shop	Helena Rubenstein's	666 N. Michigan Ave.	Fluorescent coves and downlighting
Clothing Store (Men)	Bonds	234 S. State St.	Fluorescent louvered bays
Clothing Store (Women)	Marshall Field & Co.	State & Madison	Indirect fluorescent
Drafting Room	Illinois Bell Telephone	212 W. Washington	Semi-indirect fluorescent
Music Store	Lyon & Healy	241 S. Wabash	Custom built fluorescent suspended squares
Office	Commonwealth Edison Co.	72 W. Adams St., Rm. 1296	Surface mounted glass bottom fluorescent
Restaurant	Pick Congress Corp.	500 S. Michigan	Fluorescent cove
Restaurant	Walgreens	4 N. State St.	Incandescent downlights
Restaurant	De Mets	135 S. State St.	Reverse cove cold cathode ceiling slots
Shoe Store	Chandlers	131 S. State St.	Pin hole spots, recessed louvered slimline
Street Lighting	Chicago	1600 N. Lake Shore Dr.	Mercury vapor

Here and There with I.E.S. Members

Gavel of the Student Branch at the University of Miami is presented to Branch President John K. Hughes by A. C. Bergh, Past-Chairman of the Southeast Florida Chapter and sponsor of the Student Branch at this university.

Members of the Lighting Maintenance Committee (above) inspect a "Dirtometer" at a recent meeting. This instrument was designed by the Committee to measure the effects of dust on transmission and reflectance. From left to right, standing: A. C. Barr, E. H. Church, R. D. Bradley, R. F. Townsend, L. M. Endres. Seated: R. D. Burnham, H. R. Davies, I. E. Zastrow.

Annual joint dinner meeting (right) of the Southern California Section and the Electrical Maintenance Engineers Assn. of Southern California was held at the Rodger Young Auditorium, Los Angeles.

At the Mine Lighting Committee Conference, June 19, members visited the experimental mine at Bruceton, Pa. Standing are, left to right: R. R. Richards, Ray Light, J. F. March, Arthur A. Eastman, "Mac," E. J. Coggleshall, H. M. Ferree, R. A. Wolf, R. E. Havener, J. C. Smith, Jr. Kneeling are: J. Z. Linsenmyer, E. J. Gleim, L. H. Kahler, and C. M. Crysler.

(Continued from page 8A)

on Light Sources, published monthly in IE, and to the two-day meeting of the Aviation Lighting Committee, and conferences planned for several others.

Three New Chapters

A petition for Chapter Charter was made by a group of members in Pueblo, Colorado, indicating all constitutional requirements were satisfied, and had the approval of the parent Rocky Mountain Section.

The granting of a Charter was approved for the Southern Colorado Chapter, with headquarters at Pueblo.

Following petition and report on qualifications for a Charter, the New Mexico Chapter was approved with headquarters in Albuquerque. The new Chapter will serve the state of New Mexico, formerly a part of Rocky Mountain Section.

Eastern New York Chapter, with headquarters in Albany, N. Y., was formed on approval of a Charter for this group, following presentation of a petition by Regional V-P Richard G. Slauer. The petitioning group, present as visitors to Council, were introduced by Mr. Slauer. The Albany group included C. E. Waldron, Matthew Vitartas, Don Voorhies, Art Peabody, W. J. Helpern, Bob White, Jim Jennings and Harold Friedman. The Chapter will include territory around Albany, Schenectady, Troy, Gloversville and Gens Falls, N. Y.

New Region

A. Homer Manwaring, Chairman of the Local Activities Committee, reported agreement by all Sections and Chapters and present Regions concerned, with the establishment of a new Inter-Mountain Region. Pending approval of letter ballot to a change in the By-Laws establishing ten regions instead of nine, the new Region will embrace territory including Arizona, New Mexico, Colorado, Utah, Wyoming and parts of Nevada, Idaho and South Dakota. The active Sections and Chapters within the proposed new Region have been within the boundaries of the Southwestern Region.

New Sustaining Members

On recommendation of C. C. Shotwell, Chairman, six Sustaining Members were approved as follows:

Central Louisiana Electric Co., Inc.
P. O. Box 1096
Lafayette, Louisiana
Official Representative — J. R. Gaugler

Ever-Brite Products Corp.
1629 Milwaukee Avenue
Chicago 47, Illinois
Official Representative — Jack Lipschultz

Hubbard and Company
6301 Butler Street
Pittsburgh 1, Pennsylvania
Official Representative — C. C. Warne, Jr.

Jeryl Lighting Products Inc.
42 West Cermak Road
Chicago, Illinois
Official Representative — Charles Meyerson

Mountain States Power Co.
236 Lyon Street
Albany, Oregon
Official Representative — A. T. Peterson

Nelson-Tombacher Company Inc.
81 Prospect Street
Brooklyn 1, New York
Official Representative — M. J. Tombacher

Public Relations

J. S. Schuchert, Chairman, presented in brief, a report distributed to Council mentioning especially, the following:

Section and Chapter Public Relations and Information Committees are increasingly effective.

Pages outlining I.E.S. services to the various branches of the industry have appeared in several issues of Illuminating Engineering.

The Guide "So You're in Charge of Publicity" used by Section and Chapter Committees, has been reviewed and reprinted.

The speech "I.E.S. Dividends," telling the I.E.S. story was reviewed and reprinted for distribution to Sections and Chapters.

Four News Letters over President Hib-

(Continued on page 13A)

LIGHTING CALENDAR

Society Events

September 8-12, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

August 19-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Ariz.

September 8-10, 1952 — American Standards Association's Third National Standardization Conference, Museum of Science and Industry, Chicago, Ill.

September 8-11, 1952 — Institute of Traffic Engineers, Annual Meeting, Hotel Sherman, Chicago, Ill.

September 8-11, 1952 — Fall Meeting, The American Society of Mechanical Engineers, Sheraton Hotel, Chicago, Ill.

September 29 - October 2, 1952 — Annual Convention, International Municipal Signal Association, Inc., Hotel Statler, Boston, Mass.

October 1-3, 1952 — 8th Annual Meeting, Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont.

October 1-4, 1952 — 17th Annual Conference, International Association of Electrical Leagues, Radisson Hotel, Minneapolis, Minn.

October 6-10, 1952 — Annual Convention, National Electrical Contractors Association, Hotel Morrison, Chicago, Ill.

October 7-9, 1952 — Pacific Coast Regional Restaurant Convention and Exposition, Biltmore Hotel, Los Angeles, Calif.

October 13-17, 1952 — Fall General Meeting, American Institute of Electrical Engineers, New Orleans, La.

October 20-21, 1952 — National Farm Electrification Conference, Hotel Statler, Detroit, Mich.

October 20-24, 1952 — 40th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 10-13, 1952 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 17-19, 1952 — 39th National Foreign Trade Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 19, 1952 — 34th Annual Meeting, American Standards Association, Waldorf-Astoria Hotel, New York, N. Y.

November 30 - December 5, 1952 — Annual Meeting, The American Society of Mechanical Engineers, Statler Hotel, New York, N. Y.

January 19-22, 1953 — Plant Maintenance Show, Public Auditorium, Cleveland, Ohio.

January 19-23, 1953 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 9-12, 1953 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 30 - April 2, 1953 — Annual Sales Conference, Edison Electric Institute, Edgewater Beach Hotel, Chicago, Ill.

Week of May 24, 1953 — 45th Annual Convention, National Association of Electrical Distributors, Stevens Hotel, Chicago, Ill.

June 1-4, 1953 — 21st Annual Convention, Edison Electric Institute, Atlantic City, N. J.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953 — Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953 — 25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

September 23-25, 1953 — Annual Meeting, Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont., Canada.

October 19-23, 1953 — 41st National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

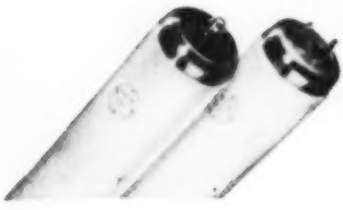
November 9-12, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

January 18-22, 1954 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 8-11, 1954 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

You expect the best value from G-E fluorescent lamps

G-E gain in light output worth more than cost of lamp



WORK WITH PRECISION INSTRUMENTS like the gigantic photometer above verifies the fact that, since 1945, the light output of General Electric fluorescent lamps has climbed 17%

Under average conditions current and maintenance account for about 90% of the cost of lighting, the lamp itself only about 10%, in commercial and industrial installations.

For this reason, General Electric's gain of 17% in light output is worth more to you than if you got your lamps free.

To give you this increase, G-E lamp research pulled more than one rabbit out of a test tube. An improved "T" phosphor with better light-giving properties. Improved phosphor manufacturing methods. Uniform end-to-end control for an even phosphor coating to give maximum efficiency.

These are a few examples of why you can *expect* the best value from G-E fluorescent lamps.

You can put your confidence in —

GENERAL ELECTRIC

(Continued from page 11A)

ben's signature and outlining important I.E.S. activities and accomplishments have been circulated to over 700 Section and Chapter Officers, Sustaining Members, and National Officers and Committeemen.

The brochure I.E.S. Dividends, based on the General Secretary's Report, was prepared and released early in April, being sent to all Sustaining Members, Section and Chapter Officers and key Chairmen, and was also distributed at the Sales Conference of the Edison Electric Institute and at the International Lighting Exposition.

Press releases have been prepared and sent out from headquarters to trade and consumer magazines covering Regional Conference programs, President Hibben's official visits, I.E.S. national events, the production of the I.E.S. Lighting Handbook and other Society publications.

Distribution of "I.E.S. Dividend Checks" at the Sales Conference of the Edison Electric Institute, and at the International Lighting Exposition, in conjunction with the Society's display exhibiting the *I.E.S. Lighting Handbook*, and leading to a drawing for the winners of copies of the Handbook.

Upon conclusion of the presentation motion was made and seconded to accept the report and to record Council's appreciation for the outstanding work of the committee including the special efforts of the committee member Harold Green, and his organization in the production of the brochure "I.E.S. Dividends."

C. L. Long, Director

Action was taken to fill the unexpired term of L. A. Hobbs, who resigned as a Director of the Society. Following presentation of candidates a ballot of Council was taken resulting in the appointment of Charles L. Long as a Director for the term October 1, 1952 to September 30, 1953.

Publications

E. C. Huerkamp, Chairman, presented a progress report for the publications program. He indicated that Illuminating Engineering was operating on a sound financial basis, and that the new editions of the *I.E.S. Lighting Handbook* would be self-supporting following final sale of the first printing.

In closing, Mr. Huerkamp noted he is concluding his service as Chairman of the Publications Committee and expressed his appreciation to the headquarters staff, and national officers for their cooperation and support in the committee's work. Mr. Manwaring congratulated the committee and staff on its success in the Publications program.

JOSEPH S. SCHUCHERT, right, receives coveted McGraw Award for cooperation, at dinner in his honor June 30. L. to r. are: George W. Ousler, Duquesne Light Co., B. D. Levaur, Pres. Electric League of Western Pennsylvania, Curtis W. McGraw, Pres. McGraw-Hill Pub. Co., who made the award, and Mr. Schuchert.

J. S. Schuchert Receives McGraw Medal for Cooperation

Joseph S. Schuchert, Manager of Commercial Sales, Duquesne Light Company, Pittsburgh, was awarded the James H. McGraw medal for Cooperation, and a check for $100, at a dinner tendered in Mr. Schuchert's honor on June 30. Members of the Electric League of Western Pennsylvania and friends in the industry from throughout the country sponsored the dinner, held at the Duquesne Club, Pittsburgh.

Curtis W. McGraw, President of the McGraw-Hill Publishing Co., New York, presented the award. In his presentation, Mr. McGraw noted that this honor came to Mr. Schuchert primarily for his work in conceiving and introducing the Planned Lighting Program in the electrical industry.

The Planned Lighting Program is devoted to raising the standards of lighting in business, industry, the home, and in commercial establishments, and through Mr. Schuchert's untiring efforts, the Planned Lighting Program has become the accepted plan nationally for conducting educational and promotional lighting programs for the industry, Mr. McGraw said.

The McGraw Award for Cooperation was established in 1925 by James H. McGraw, to be given annually if justified, in recognition of the most important personal contributions to progress in the electrical industry. Only 19 such awards have been given during the 27 years since Mr. McGraw established the award, the last recipient being Charles E. Wilson, President of General Electric Company, who received the award in 1950.

B. D. Levaur, President of the Electric League of Western Pennsylvania, presided, and Ralph Wagner, Niagara Mohawk Power Corporation, Albany, presented Mr. Schuchert with an album depicting the Planned Lighting Program from its inception. Brief talks were given by Mr. McGraw and G. W. Ousler, Vice-President of Duquesne Light Company, praising Mr. Schuchert for his part in improving the general standards of Lighting throughout the United States.

I.E.S. Group Active in Duluth-Superior

A very active group of I.E.S. members in the Duluth-Superior area have been organizing local meetings in that neighborhood. A particularly successful one was held May 20, attended by 36 local members and 12 I.E.S. member-visitors from Minneapolis. George Spurbeck, acting "chairman" of the group presided.

Speakers at the meeting included L. J. Riegert, Chairman of the Twin City Section of I.E.S., and Win Close, Advisory Architect for the University of Minnesota. Main speaker was L. E. Johnson, Northern States Power Co., Minneapolis.

Mr. Riegert outlined benefits from active membership in I.E.S., while Mr. Close told the group about the work being done by the Twin City Section at the University of Minnesota. He showed a

(Continued on page 14A)

DULUTH-SUPERIOR members heading toward Chapter Charter. Several of the men responsible for the well organized meetings being held in Duluth are, in the usual order, photo at left: Robert D. Coons, Robert E. Steele, Lawrence E. Johnson, Merrill Pearson, L. B. Paist, Regional V-P, elect; photo at right: R. E. Olsen, L. J. Riegert, George B. Spurbeck, Carl T. Bremicker, Winston Close.

(Continued from page 13A)

large model of the Duluth campus to illustrate his talk.

Mr. Johnson gave a very interesting history on lighting and lighting methods, a subject well received by the audience.

The evening was topped off with an invitation by Mr. Bob Coons of the Northern States Power Company, Membership Chairman of the Twin City Section, and Bob Olsen, Program Co-chairman, Twin City Section, to the members in the Duluth Superior area for the Fishing Get-Together sponsored by the Twin City Section on June 13th.

Organization of the group already in- tional meetings are planned for the summ- cludes a Program Chairman and addi- mer months. Petition for an I.E.S. Chapter Charter is expected to be the new Regional V-P's (L. B. Paist) first official act at October Council.

British I.E.S. Meets At Eastbourne

The bi-annual convention of the British Illuminating Engineering Society was held May 20 to 23 in Eastbourne, England, with some 340 members and visitors registered for the meeting. The subject of "brightness engineering" was the underlying theme of the papers presented, and according to the Society's official journal *Light and Lighting*, that phase of lighting practice was of special interest to the delegates.

Among the foreign visitors at the convention was our own Henry L. Logan, Director of Research for Holophane, New York. Mr. Logan delivered the second paper of the meeting "Two Frontiers of the Lighting Art," which was a continuation of the theme presented by Dr. Ward Harrison before the British I.E.S. in 1948 titled "Some Frontiers of the Lighting Art." The paper and subsequent discussion occupied one afternoon session. The session was attended to capacity with keen interest shown in the subject. Discussion largely centered on the desire of the various speakers for further amplification and more information than could be compressed into the time allotted for the paper.

Other foreign registrants included Henri Maisonneuve, Jean Chappat and Jean Maisonneuve from Paris; Mr. and Mrs. E. C. Hugh of New York; L. C. Kalff and Johan Jansen of Eindhoven; and Mr. and Mrs. B. Kundsen of Copenhagen. The Eastbourne meeting more than upheld the reputation of the British I.E.S. for excellent and valuable papers sessions. As in other years, a limited number of papers were planned, emphasis being on extensive discussion periods. Some of the subjects presented included, in addition to the Logan paper already mentioned:

"The Eye, Brightness and Illuminating Engineering," by Dr. W. S. Stiles.

"Lighting in the Design of Schools," by Anthony Pott.

"The Design of Interior Lighting Equipment," by L. H. Hubble.

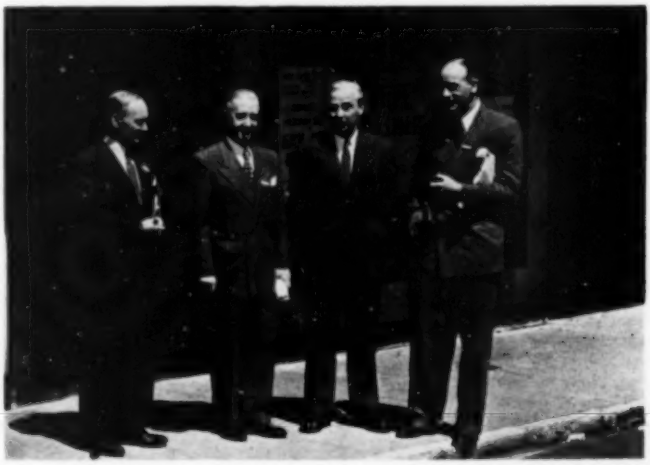
"Problems of Underwater Illumination," by W. D. Chesterman and J. B. Collins.

"Interior Lighting Development in the Netherlands," by L. C. Kalff.

C.I.E. Proceedings Of 1951 Sessions

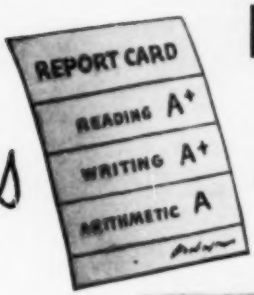
The United States National Committee of the Commission Internationale de l'Eclairage (I.C.I.) reports that they have had a nice response to the sale of the Proceedings of the Congress at Stockholm. They report that a few of these books remain and will be supplied upon request as long as they last. They noted that in some previous years not every

(Continued on page 16A)



FOUR of the overseas visitors to the recent successful Summer Meeting of the (British) Illuminating Engineering Society, held at Eastbourne, England. L. to r., Dr. S. English, Managing Director of Holophane Ltd.; H. L. Logan, Holophane Co. Inc., New York, who addressed the meeting on "Two Frontiers of the Lighting Art"; J. G. Holmes, President of the British I.E.S.; and W. T. F. Souter, Sales Director of Holophane Ltd.

BETTER LIGHTING assures better learning



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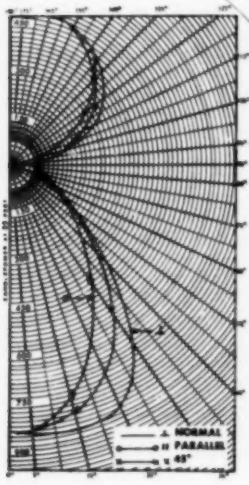

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GARCY lighting equipment

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(Continued from page 14A)

one who has wished a copy has requested it in time and wish to make sure that the available remaining copies are distributed to the interested persons.

These records of the Papers and Secretariat Reports, officially known as Compte Rendu, Proceedings, Stockholm, 1951, comprise two bound volumes containing nearly 1,500 pages. They are available at a price of $12.50 per set. Orders should be sent to Mr. T. D. Wakefield, Treasurer, United States National Committee, C.I.E., % F. W. Wakefield Brass Company, Vermilion, Ohio.

Election of New I.E.S. Officers

At a meeting of the I.E.S. Council held June 18, 1952, the report of the Committee of Tellers was presented, giving the results of the recent election of officers for the coming year, beginning October 1, 1952. The following have been elected to the offices indicated:

General Officers

President—Everett M. Strong, Cornell University, Ithaca, N. Y.

Vice-Presidents—Duncan M. Jones, Curtis Lighting Co. of Canada, 19 Ballantyne Ave. N., Montreal W., Que.; A. H. Manwaring, Phila. Elec. & Mfg. Co., Philadelphia, Pa.

General Secretary—C. C. Keller, Holophane Company, Inc., New York, N. Y.

Treasurer—Kirk M. Reid, General Electric Co., Nela Park, Cleveland, Ohio.

Directors (Until 1955)—J. F. Whitehead, Jr., Day Brite Lighting Inc., 5411 Bulwer Ave., St. Louis, Mo., and F. C. Winkler, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

(Until 1954)—G. W. Beals, The Miller Co., Meriden, Conn.; J. S. Schuchert, Duquesne Light Co., Pittsburgh, Pa.

(Until 1953)—C. R. Long, Westinghouse Electric Corp., Los Angeles, Calif.; R. A. Palmer, Duke Power Co., Charlotte, N. C.

Regional Vice-Presidents—Great Lakes Region, L. C. Twitchell, Rochester Gas & Electric Corp., Rochester, N. Y.; Midwestern Region, L. B. Faist, Northern States Power Co., Minneapolis, Minn.; Northeastern Region, George J. Taylor, Day Brite Lighting, Inc., New York, N. Y.; Pacific Northwest Region, Walter J. Lind, Canadian General Electric Co. Ltd., Vancouver, B. C. and South Pacific Coast Region, L. A. Hobbs, Smoot-Holman Co., Inglewood, Calif.

(Until 1953)—Canadian Region, F. P. Labey, Northern Electric Co., Ltd., Montreal, Que.; East Central Region, P. H. Hildebrand, Penna. Power & Light Co., Allentown, Pa.; Inter-Mountain Region, H. T. Rankin, Public Service Co. of Colorado, Denver, Colo.; Southern Region, R. C. Paslay, Louisiana Power & Light Co., New Orleans, La.; Southwestern Region, W. E. Folsom, Dallas Power & Light Co., Dallas, Tex.

British Columbia Section

Chairman—Paul Donnelly, Northern Electric Co. Ltd., Vancouver, B. C. *Secretary*—D. S. Gordon, British Columbia Electric Railway Co. Ltd., Vancouver, B. C. *Board of Managers*—E. E. Ackland, Thomas H. Doherty, Gordon Hamm, G. W. Hutchinson, Arthur A. Jones.

Capital Section

Chairman—C. G. Estabrook, Anderson & Estabrook, Inc., Arlington, Va. *Vice-Chairman*—C. R. Engle, Jr., General Engineering Associates, Washington, D. C. *Secretary-Treasurer*—Dorothy Nickerson, U. S. Department of Agriculture, Cotton Branch, Washington, D. C. *Board of Managers*—B. G. Goodman, J. C. Melton, H. C. Smith, R. P. Teele.

Central New York Section

Chairman—Warren H. Lawrence, Gould Farmer Co. Inc., Syracuse, N. Y. *Vice-Chairman*—Daniel L. Killigrew, Corning Glass Works, Corning, N. Y. *Secretary-Treasurer*—Robert H. Goodman, Crouse-Hinds Co., Syracuse, N. Y. *Board of Managers*—Casper L. Cottrell, George W. Levevance, William H. Parsons and Carleton L. Peckham.

Chicago Section

Chairman—William A. Weibel, Curtis Lighting Co., Chicago, Ill. *Vice-Chairman*—James R. Chambers, Benjamin Electric Mfg. Co., Des Plaines, Ill. *Secretary*—Arthur P. Larson, Commonwealth Edison Co., Chicago, Ill. *Board of Managers*—Robert J. Diefenthaler, R. Ralph Lusk, John H. Pierce, Gilbert I. Stadeker.

Cleveland Section

Chairman—D. W. Rowten, Westinghouse Electric Corp., Cleveland, Ohio. *Secretary*—Robert Morris, General Electric Co., Cleveland, Ohio. *Board of Managers*—L. O. Banahan, L. J. Cahill, Wayne Culp, Merle Keck and M. A. Mortensen.

Connecticut Section

Chairman—Francis Clark, Francis Clark Services—Lighting, Waterbury, Conn. *Vice-Chairman*—Edward R. Cole, Hartford Electric Light Co., Hartford, Conn. *Secretary-Treasurer*—Raymond O. Mills, The Connecticut Light & Power Co., Waterbury, Conn. *Board of Managers*—F. E. Brown, Jr., C. W. McCormick, L. A. Senofonte, and H. B. Sohn, Jr.

Eastern Pennsylvania Section

Chairman—E. W. Halteman, Pennsylvania Power & Light Co., Bethlehem, Pa. *Vice-Chairman*—Miles H. Keiffer, Electric Engineering & Construction, Manheim, Pa. *Secretary*—P. A. Kinsey, Metropolitan Edison Co., Reading, Pa. *Board of Managers*—P. E. Aumen, J. S. Freeman, Ford M. Gochenauer, and E. W. Kelsey.

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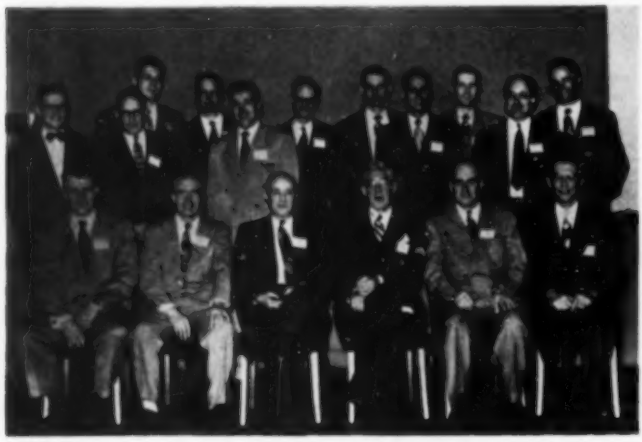
Chairman—J. Dixon Mitchell, Jr., Westinghouse Electric Corp., Chamblee, Ga. *Vice-Chairman*—H. R. Chappell, Whitehead Electric Co., Atlanta, Ga. *Secretary-Treasurer*—J. E. McComack, Noland Co. Inc., Atlanta, Ga. *Board of Managers*—R. H. Hiller, Judd Lough, T. Taylor Peake, J. E. Sweatte.

Heart of America Section

Chairman—Willard L. Stiers, Sylvania Electric Products Inc., Kansas City, Mo.

(Continued on page 19A)



ALUMNI contingent from Case Institute of Technology who attended the Great Lakes Regional Conference are, left to right: Seated, Kenneth Epple, J. A. Meacham, G. W. Beals, S. G. Hibben, R. C. Putnam, and R. L. Zahour; standing, Wayne Culp, Lindsey Davis, Thomas Wood, Theodore Ake, Jr., A. H. Stevenson, O. J. Holian, David Pritchard, John Neidhart, H. A. Lawrence, and F. L. Detwiler.

eyes come first with new BENJAMIN "Grid-Lite" system

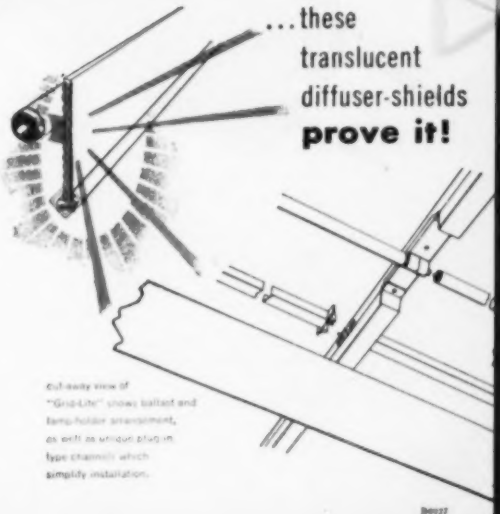
translucent diffuser shields provide more comfortable seeing . . . meet Educators' demand for an atmosphere that inspires attentiveness, eliminates distractive contrasts and promotes voluntary concentration.

translucent diffuser shields are the answer to MORE LIGHT . . . as much as 10% MORE LIGHT than with opaque louvers . . . and, combined with "Grid-Lite" System, up to 50% MORE LIGHT than conventional luminaires!

Benjamin engineers designed "Grid-Lite" with but one objective: better comfort-brightness balance and more light. This is the kind of light educators have long sought . . . there can be no compromise in attaining it. That is why "Grid-Lite" utilizes translucent, ribbed polystyrene diffuser shields, instead of less efficient opaque shields, louvers or other shielding media. Benjamin diffuser-shields actually *raise the total usable light* on the working surface, while providing a new high in comfort-brightness balance through greater light diffusion and 45° lamp shielding.

Young America's eyes deserve this kind of restful, diffused light. It promotes concentration and attention . . . it eliminates disturbing contrasts that develop glare, germinate unrest and carelessness . . . it creates a stimulating atmosphere conducive to better study habits.

It is because SEEING is youth's main gate to knowledge, that EYES COME FIRST with "Grid-Lite"! For further details and lighting data, write for FREE "Grid-Lite" Bulletin, AD 5080, just published. Benjamin Electric Mfg. Co., Dept. I, Des Plaines, Ill.



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NEW lead-lag slimline ballast

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An *exclusive*, new design for slimline *lead-lag* ballasts slashes prices, sizes, and weights to series ballast levels . . . yet provides lead-lag dependability. This means long-range economy for your customers. Longer lamp life . . . full-rated lamp life . . . no more guesswork about lamp burnouts. A real savings in maintenance time and money. Get the full story on the new Westinghouse *lead-lag* ballast. Send for B-5614, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-04317

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(Continued from page 16A)

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Montreal Section

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PORTABLE headquarters display developed by the New England Section for exhibit at meetings and Regional Conferences. All I.E.S. publications are available for examination, and order blanks make on-the-spot ordering easy.

New Orleans Section

Chairman—H. W. Gregory, Gregory and Salisbury and Co., New Orleans, La. *Vice-Chairman*—H. T. Bailey, Jr., Louisiana Power and Light Co., Gretna, La. *Secretary-Treasurer*—J. M. Genasburger, New Orleans Public Service, Inc., New Orleans, La. *Board of Managers*—S. C. Berdon, Sam Calhoun, Mabel K. Landrum and A. A. Levy.

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Northern California Section

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Ohio Valley Section

Chairman—R. J. Schulte, General Electric Co., Cincinnati, Ohio. *Vice-Chairman*—Donald G. Bertke, Bertke Electric Co., Cincinnati, Ohio. *Secretary*—Edward J. McGinnis, Cincinnati Electric Association, Cincinnati, Ohio. *Board of Managers*—Stella M. Fetzer, Joachim A. Kristof, Herman Meierjohan and William V. Misrach.

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Pittsburgh Section

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Puget Sound Section

Chairman—C. A. Scheyer, Puget Sound Power & Light Co., Seattle, Wash. *Secretary*—G. D. King, Sylvania Electric Products Inc., Seattle, Wash. *Board of*

(Continued from page 19A)

Managers—Raymond E. Adam, C. C. Fields, C. K. Fulton, F. C. Scharr, W. D. Williams.

ROCKY MOUNTAIN SECTION

Chairman—Ferman Bischofberger, Public Service Co. of Colorado, Denver, Colo. *Vice Chairman*—Arthur F. Weers, Weers Electrical Planning Service, Denver, Colo. *Secretary-Treasurer*—Carl W. Strain, General Electric Co., Denver, Colo. *Board of Managers*—Charles D. Bell, G. R. Buck, H. S. G. Neumann and Alvin D. Swanson.

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Chairman—Joe L. Booker, General Electric Co., Nashville, Tenn. *Secretary*—D. L. McClearen, Tennessee Valley Authority, Nashville, Tenn. *Board of Managers*—H. F. Collins, Jr., May Love Gale, S. R. LeCorgu, Charles H. Patterson and J. L. Simpson, Jr.

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WESTERN NEW YORK SECTION

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Survey Indicates Engineer Shortage To Continue

The number of electrical engineers graduated this past June is insufficient to ease the industry-wide shortage, according to a survey of 112 American engineering colleges, made by the magazine, *Electronics*.

From the colleges surveyed, roughly 80 per cent of the nation's total, only 3,450 graduate electrical engineers are available for employment. Industry estimates that 5,000 are needed to fill vacancies created by death and retirement, and to meet growing commercial needs. Defense production alone could easily assimilate twice that number, the magazine reports.

The 3,450 does not include the ten per cent of the graduates who are definitely committed to the armed forces, or the eight per cent who have applied for graduate work.

ABOUT PEOPLE

William F. Little, formerly Engineer in Charge of Photometry at Electrical Testing Laboratories, Inc., New York, N. Y., has been appointed Vice-President of E.T.L. Mr. Little was President of the Illuminating Engineering Society in 1930-1931 and in 1950, he was awarded the I.E.S. Gold Medal.

Dr. Richard Feinberg was elected president of the Northern Illinois College of Optometry, Chicago, Ill. becoming the fifth president of that institution in 80 years. Dr. Feinberg came to the college last fall as dean, having previously served as dean of the College of Optometry at Pacific University.

Robert F. Johnson has been appointed manager of the Parts Manufacturing Department of General Electric's Lamp Division, filling the post left vacant by the death of **Frank C. Perkins**. Mr. Johnson was formerly manager of the East Boston Lamp Works of that company. He is succeeded in this position by **C. Fred Roda**.

Retirement of **George A. Goerss** and appointment of **Erwin E. Lehmann** to succeed him as manager of the General Electric Co.'s Euclid Lamp Works in Cleveland have been announced.

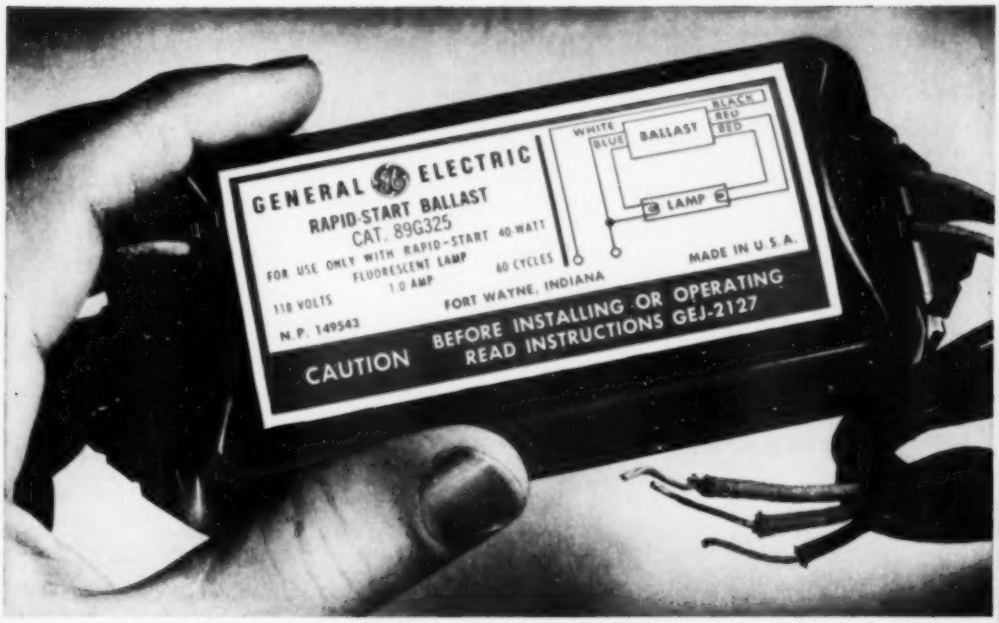
V. J. Fucigna has been appointed manager of lighting sales for the New York District of Garden City Plating and Manufacturing Co. Mr. Fucigna was, for the past eight years, District Lighting Specialist for the General Electric Supply Corp.'s New York office.

George F. Hessler, vice-president of Graybar Electric Co., Inc., received the Distributor's Medal, James H. McGraw Award for Electrical Men, at the annual convention of the National Association

(Continued on page 23A)

Tentative Schedule — I.E.S. Regional Conferences, 1953

Canadian	Chateau Laurier Ottawa, Ont.	March 23-24
Southwestern	Hotel Baker Dallas, Tex.	April 12-14
Pacific Northwest	Multnomah Hotel Portland, Ore.	April 23-24
Midwestern	Minneapolis, Minn.	Week of May 6
East Central	Hotel Lord Baltimore Baltimore, Md.	May 14-15
Southern	Sedgefield Inn Greensboro, N. C.	May 18-19
Great Lakes	Syracuse Hotel Syracuse, N. Y.	May 25-26



THE GREEN LABEL DISTINGUISHES NEW G-E 40-WATT RAPID-START BALLAST FROM OTHER G-E BALLASTS—NOTE SIMPLIFIED CIRCUIT

New G-E Lighting Development

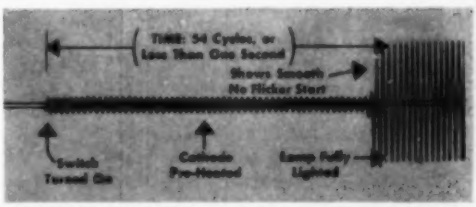
40-watt RAPID-START system eliminates starters

General Electric—first to introduce fluorescent lighting in 1938—now brings you a starterless system giving full, rated lamp life. New, electrically matched 40-watt **RAPID-START** lamps and ballasts do away with bothersome blinking at end of lamp life, give you eye-easy, no-flicker starts at a touch of the switch!

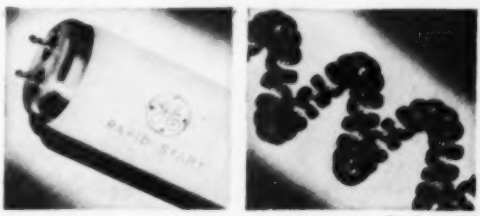
Present "instant-start" 40-watt fluorescent is costly, uses a heavier ballast—present "switch-start" is complicated by auxiliary starters and wiring—new **RAPID-START** system features smaller, lighter ballasts at a lighting cost comparable to 40-watt switch-start lighting.

General Electric lamp and ballast engineers have again combined their efforts to bring you a revolutionary development in 40-watt fluorescent lighting—the volume market. For new installations or to modernize old installations—a sales plus your customers will want! Act today. Contact your nearest G-E Apparatus Sales Office, or write Section 412-102, for complete information. General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC


TIME: 54 Cycles, or Less Than One Second
Shows Smooth No Flicker Start
Switch Turned On
Cathode Pre-Heated
Lamp Fully Lighted

ENGINEER'S ANALYSIS of oscillograph readings shows fast, no-flicker pre-heated cathode action of new G-E Rapid-Start.



Greatly magnified

NEW G-E BIPIN LAMP, especially developed for fast, pre-heat starting, employs complex, triple-coiled cathode, right.

another NEW SOLA ballast development

Dynatran
TRADEMARK
BALLASTS

The LIGHTEST and SMALLEST LEAD-LAG BALLAST* ever produced

Here is the answer to your fluorescent lighting problems. A new premium performance ballast that is outstanding. It is comparable in size and wattage loss to current models of certified "Sequenstart" ballasts. *The new Dynatran is certified by E. T. L. to comply with the present Spec. #6, and the proposed American Standards Association specification C82.1. It provides these advantages:

- *Independent lamp operation*
- *Small size, light weight*
- *High starting current*
- *Fast lamp starting*
- *Low wattage loss*
- *Low peak to R. M. S. current ratio*
- *More Lumens per watt*
- *Cool operation and low temperature rise*
- *Ventilated capacitor compartment for longer ballast life*
- *Quiet operation*
- *Stroboscopic correction*
- *Low Cost*

Designed in the tradition of Sola engineering leadership

SOLA *Fluorescent* BALLASTS

NEW TECHNICAL LITERATURE is now being prepared. It gives mechanical and electrical specifications of the new Dynatran Ballasts. Write on your letterhead for **BULLETIN C-PFL-165.**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs Oil Burner Ignition • X-ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 39, Illinois New York: 103 E. 125th St., New York 35, N.Y., THafalgar 6-6464 • Cleveland: 1010 Euclid Ave., Cleveland 15, O., PRospect 1-4065 Boston: 246 Walnut St., Newtonville, Mass., DEcatur 2-3310 • Philadelphia: Commercial Trust Bldg., Rittenhouse 6-4988. Reps. in Principal Cities

(Continued from page 20A)

of Electrical Distributors in Atlantic City, June 11. Mr. Hessler received the award in recognition of his constructive

H. B. Gould, Superintendent of Electric and Steam Sales of the Youngstown, Ohio, Division of the Ohio Edison Co., has been appointed Chairman of the Commercial and Industrial Education Committee of the Better Light Better Sight Bureau.

John Cornish has been named Manager of Export Sales for the Miller Company, Meriden, Conn. Formerly manager of the company's New York office, Mr. Cornish will continue to make his headquarters at 33 West 42nd St. He is succeeded in the New York office by **John J. Slevin,** formerly field sales engineer.

James H. McCulloch, formerly development engineer for Sunbeam Lighting Co., has joined the fluorescent ballast engineering section of the General Electric Co. at Fort Wayne, Indiana.

OBITUARIES

Arthur H. Molitor, member of the Society for more than 25 years, died recently. He is mourned by his many friends in the Michigan Section and in the lighting industry.

Harry C. Lynde, founder of the Harry C. Lynde Company and active in the lighting field for 35 years, died July 5. He was a member of the Puget Sound Section of the I.E.S.

Dr. Lonisa Paine Tingley, physician and ophthalmologist, died July 16 at her home in Boston. Dr. Tingley was well known for her pioneering work as a woman and doctor.

IT SEEMS TO ME

The Lion Project

A new tool for visual research has been developed at the Massachusetts Institute of Technology by Professor Kurt S. Lion. On a research grant from the Illuminating Engineering Society for a project entitled "Work Done by the Extrinsic Ocular Muscles," he has produced an electronic method of measuring and automatically recording the angular displacement, angular velocity, and angular acceleration of the eyeball.

The apparatus[1] appears to be satisfactory. It is on the *interpretation* of the results that I should like to comment. The tests indicate that after an observer has performed a difficult visual task for some time, he still moves his eyes through approximately the same angle and at approximately the same velocity and acceleration. This is, of course, in agreement with the conclusions of Luckiesh, who has preached for 20 years or more that one can force himself to perform a visual task even under very adverse conditions. Dr. Lion's conclusion, however, seems to be that there is no such thing as fatigue of the extrinsic muscles of the eye.

I wish to make three specific comments on the interpretation:

(1) Dr. Lion assumes that muscular force is directly proportional to angular acceleration. This would be true only in the case of a pure inertial system, which we certainly do not have.

(2) Dr. Lion equates the decrement of this so-called "force" to "muscular fatigue," a step that is questionable.

(3) The Illuminating Engineering Society is not vitally concerned with "visual fatigue" (whatever that may be) but is very much interested in a practical criterion for quality of lighting. *The Lion apparatus may provide us with a quantitative method of specifying how good a lighting system really is from the visual standpoint.* For this reason, the research should certainly be continued.

Inspection of Dr. Lion's oscillograms shows that the eye motions change markedly under adverse conditions. Thus, when rested or when working in an ideal visual environment, the eye will perform a given visual task with precision and with a minimum of unnecessary motions. But when the eye tries to see under adverse visual conditions or when a sense of fatigue is experienced the motions become more complex. Figure 1 shows oscillograms from Dr. Lion's flashing light tests, in which the subject tried to follow two alternately flashing lights, 90 degrees apart, at a rate of 120 to 150 changes per minute. In Fig. 1 (a) curve A is taken at the start of the test, B after 5 minutes, and C after 10 minutes. As fatigue sets in, the departure from the optimum eye movement increases. Curve 1 (b) shows the difference between A and B, while curve 1 (c) shows the difference between A and C. It will be noticed that the departure from the optimum motion is about twice as large at 10 min. as it is after 5 min. Figure 2 gives corresponding results for another subject. The pattern of reaction of this subject is somewhat different, but the general conclusion is that when the sensation of fatigue is experienced, the motions of the eye differ greatly from the simple pattern that is obtained under ideal visual conditions.

In these variations of patterns of eye motions we have the nucleus of a significant advance in illuminating engineering. If we can correlate the oscillograph variations with the specification of the visual environment, progress will have been made.

The next step in the Lion research should be to test the eye motions in a controlled luminous environment and for

(Continued on page 24A)

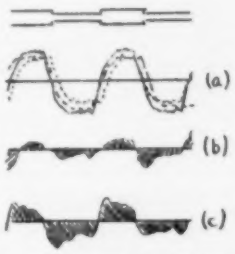


Fig. 1. Oscillograms for flashing light test.

(a) A, at start of test
B, after 5 minutes
C, after 10 minutes
(b) difference between A and B
(c) difference between A and C

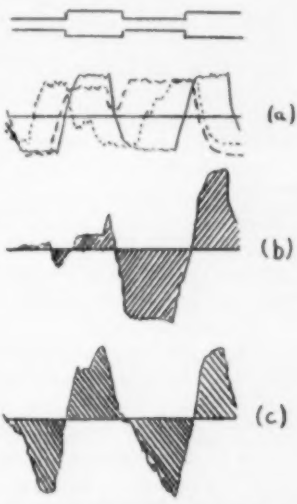


Fig. 2. Similar results for a different observer.

(Continued from page 24A)

some typical practical visual tasks. The variation of the eye motion pattern should be studied, first as quantity of light is varied with a *uniform surround* and then as direct and reflected glare sources are superimposed on the uniform field.

Dr. Lion's project is not finished. He has barely begun. He has developed excellent instrumentation for measuring eye motions. The work should be completed in collaboration with an illuminating engineer who can design and control the luminous environment. A correlation should be established between the eye motions and the luminous environment. It is to be hoped that the I.E.S. Research Committee will realize the importance of this work and will provide funds for its continuation.—DOMINA EBERLE SPENCER, *University of Connecticut, Storrs, Conn.*

1. Edward R. Ponsner and Kurt S. Lion, "Testing Eye Muscles," *Electronics*, March 1950.

NEW MEMBERS

At the meeting of the Council Executive Committee held in New York, N. Y. on July 10, 1952, the following were elected to membership:

CAPITAL SECTION

Associate Member:
Cole, Marion W., 3202 Avenham Ave., S.W., Roanoke, Va.

CAROLINAS CHAPTER

Member:
Dukes, R. C., Dukes & Dukes, Inc., Orangeburg, S. C.

CENTRAL ILLINOIS CHAPTER

Associate Members:
Birkey, W. R., Central Ill. Public Service Co., Beardstown, Ill.
Crist, L. B., Cristal Electric, Peoria, Ill.

CENTRAL NEW YORK SECTION

Members:
Bannigan, J. C., Niagara Mohawk Power Corp., Utica, N. Y.
Hartman, T. S., Niagara Mohawk Power Corp., Syracuse, N. Y.
McGuinness, R. F., Niagara Mohawk Power Corp., Utica, N. Y.
Stebbin, K. S., Niagara Mohawk Power Corp., Watertown, N. Y.

CHICAGO SECTION

Member Emeritus:
Tilson, E. D., 2507 Lincoln St., Evanston, Ill.

Member:
Passman, N. E., Nepo Mfg. Co., Chicago, Ill.

Associate Members:
Christman, B. C., General Electric Co., Chicago, Ill.
Fears, F. L., Crouse Hinds Co. Chicago, Ill.
Horton, F. C., Jr., General Electric Co., Chicago, Ill.
Johnson, Bert, Public Service Co. of No. Ill., Maywood, Ill.

CLEVELAND SECTION

Associate Members:
Nehus, J. R., Central National Bank, Cleveland, Ohio.
Dean, K. R., General Electric Co., Cleveland, Ohio.

CONNECTICUT SECTION

Member Emeritus:
Tuck, D. H., Redding Ridge, Conn.

CORNHUSKER CHAPTER

Associate Member:
Murphy, R. A., 308 Iowa St., Sioux City, Ia.

EASTERN NEW YORK CHAPTER

Member:
Ohlenheimer, J. L., 373 State St., Albany, N. Y.

EASTERN PENNSYLVANIA SECTION

Associate Member:
Garnet, E. R., Raub Supply Co., Lancaster, Pa.

FLORIDA CHAPTER

Associate Member:
Young, M. A., Jr., Graybar Electric Co., Tampa, Fla.

FOREIGN NON-SECTION

Associate Members:
Nicholson, H. J. G., Australian General Electric Pty. Ltd., Adelaide, South Australia.
Smith, H. S., OSRAM General Electric Lamp Works, Hammersmith, London, England.

GEORGIA SECTION

Associate Member:
Foster, E. B., P. O. Box 549, Sheffield, Ala.

INLAND EMPIRE CHAPTER

Associate Member:
Loiseau, E. E., Electric Smith Inc., Spokane, Wash.

MARYLAND SECTION

Student Member:
Lolie, Edward, Jr., Egli & Gompf Inc., Baltimore, Md.

MILWAUKEE SECTION

Associate Members:
Geppa, L. A., Salter Electric Co. Inc., Waukesha, Wis.
Smith, F. G., Graybar Electric Co., Milwaukee, Wis.

NEW ENGLAND SECTION

Associate Members:
Galopin, F. E., Sylvania Electric Products Inc., Danvers, Mass.
Garnick, Philip, Fisher Pierce Co. Inc., S. Braintree, Mass.
Masters, S. A., 129 Lisbon, Lewiston, Maine.

NEW ORLEANS SECTION

Associate Member:
Schroeder, G. C., Jr., Louis N. Goodman & Associates, New Orleans, La.

NEW YORK SECTION

Member:
Till, W. S., Westinghouse Electric Corp., Bloomfield, N. J.

Associate Members:
Heine, T. H., Westinghouse Electric Corp., Bloomfield, N. J.
Jaeger, G. L., Westinghouse Electric Corp., Bloomfield, N. J.

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Cronkite, L. T., Pacific Gas & Electric Co., San Jose, Calif.

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Clausius, L. L., Roy M. Butcher Electric Co., San Jose, Calif.
Lehr, W. J., George Erskine & Associates, Menlo Park, Calif.
McNamee, F. B., Incandescent Supply Co., San Francisco, Calif.
Morishige, T., Kaiser Engineers, Oakland, Calif.
Sander, W. H., George S. Erskine & Associates, Menlo Park, Calif.
Smith, Gene, Buckles Smith Co., San Jose, Calif.

OKLAHOMA CHAPTER

Associate Members:
Dunbney, K. C., Douglas Aircraft Co. Inc., Tulsa, Okla.
West, H. O., Public Service Co. of Okla., Tulsa, Okla.

OREGON SECTION

Members:
Emory, G. H., Emory & Bohm Electric Co., Portland, Ore.
Johnson, H. P., 240 W. 1st Ave., Albany, Ore.
White, C. C., Jr., Myers & White, Portland, Ore.

Associate Member:
Crane, Ross, Luxor Lighting Products, Inc., Portland, Ore.

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Associate Member:
Graubard, Nathan, 52nd St. & Montgomery Ave., Philadelphia, Pa.

PITTSBURGH SECTION

Associate Member:
Winther, W. R., Champion Lamp Works, Lynn, Mass.

PUGET SOUND SECTION

Member:
Fulton, C. K., General Electric Co., Seattle, Wash.

SAN JACINTO SECTION

Associate Member:
Rupp, Charles, General Lighting & Equipment Co., Houston, Texas.

SOUTHERN CALIFORNIA SECTION

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McKenzie, Stuart, Wagner-Woodruff Co., Los Angeles, Calif.

Associate Members:
Meyerson, S. I., Clayton T. Gibbs, Los Angeles, Calif.
Davis, C. F., Ray J. Noel Co., Los Angeles, Calif.
Howard, J. H., Southern California Edison Co., Los Angeles, Calif.
Noel, R. J., Sr., Ray J. Noel Co., Los Angeles, Calif.
Shalda, William, Shalda Mfg. Co. Inc., Burbank, Calif.

Student Members:
Bristow, K. G., University of Southern California, Los Angeles, Calif.
Rousellot, M. A., University of Southern California, Los Angeles, Calif.
Somoskovy, W. J., Los Angeles College of Optometry, Los Angeles, Calif.

SOUTHERN COLORADO CHAPTER

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Shanks, W. C., Colorado Broadcasting Co. Inc., Pueblo, Colo.
Thornburgh, W. D., American Electric Co., Pueblo, Colo.

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Winniford, J. C., Cockrell Electric Co., Dallas, Texas.

CEILING OF LIGHT

New! Leaderall Suspension Clips

New grooved suspension clips of steel hold louvered plastic units firmly at end of adjustable tie rods to form a completely level, rigid ceiling at any desired height.

For joining 2 end-to-end sections

For 4 intersecting sections

For finishing individual corners

High footcandles...low brightness

Leader's plastic louvered ceiling provides light from wall to wall, evenly distributed and properly shielded for maximum efficiency, freedom from glare, and minimum shadows. The Leaderall grilles are easily installed, instantly removable... feather light, yet tough and warp-proof. May be used with any type of fluorescent fixture, in finishing new ceilings or remodeling old ones. No interference with air conditioning or sprinkler systems. Ideal lighting for drafting rooms, a wide variety of commercial interiors, offices, cafeterias.

Sold and installed by the better electrical wholesalers and contractors

Leader® *America's No. 1 Lighting Equipment Manufacturer*

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—the lid is off the ***most important news in lighting today!***

Announcing the Ultimate in Creative Recessed Lighting

MITCHELL ***uni-flow*** **fluorescent troffers**

when you plan for the best in recessed lighting, specify uni-flow

Here is a picture preview of the MITCHELL UNI-FLOW Fluorescent Troffer . . . completely new . . . dramatically different and superior . . . years ahead of anything in the recessed lighting field. What you are looking at is the result of two full years of development work that has paid off in a product so advanced and improved that the architects, contractors, utility men and wholesalers who have had an opportunity to examine it, say unanimously: "*This is it!*"

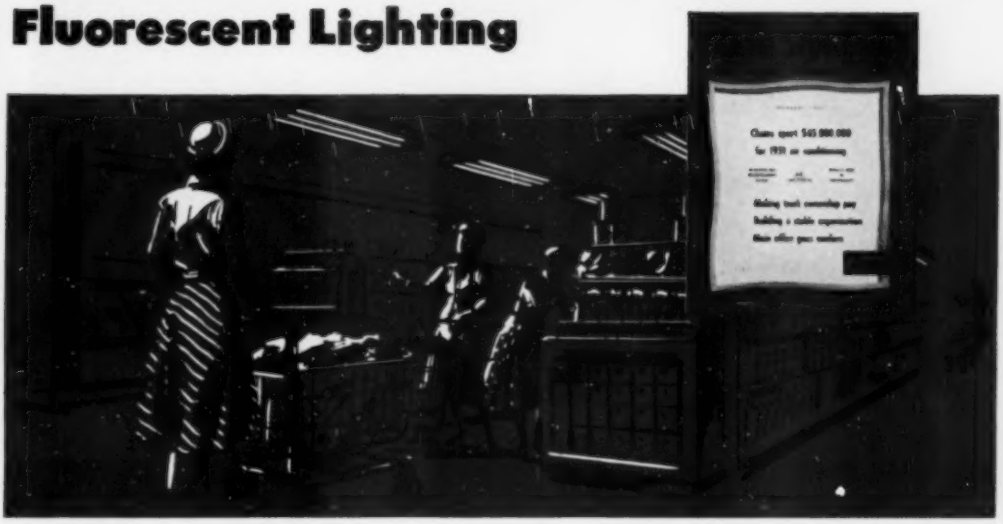
If you are now planning a recessed lighting installation, you owe it to your customers, your clients and yourself to learn the full facts about MITCHELL UNI-FLOW. Write, phone or wire today for the most important news in recessed fluorescent lighting.

MITCHELL MANUFACTURING COMPANY, 2525 N. CLYBOURN AVE., CHICAGO 14, ILL.

In Canada: Mitchell Mfg. Co., Ltd., 19 Waterman Ave., Toronto

Send for it! Address Dept. 3-H

Chain Store Age Recommends CERTIFIED BALLASTS for Fluorescent Lighting



CHAIN STORE AGE, in advising chain store operators on their selection of fluorescent lighting equipment, said:

"The ballast is the heart of a fixture. The surest way to choose a ballast is to look for the Certified shield . . . it is the only assurance of long lamp life. Inferior ballasts delivering wrong wattages result in low light output."

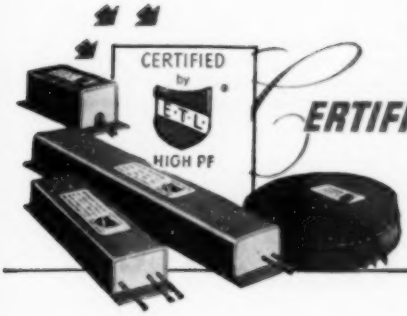
Experience has proved that CERTIFIED BALLASTS assure:

Full Lamp Life **Rated Light Output** **Maximum Ballast Life**

CERTIFIED BALLASTS are made to precise specifications, then tested by Electrical Testing Laboratories, Inc., which certifies they conform to these high standards.

Write for complete information on the types of CERTIFIED BALLASTS available from each participating manufacturer.

Participation in the CERTIFIED BALLAST program is open to any manufacturer who complies with the requirements of CERTIFIED BALLAST MANUFACTURERS.

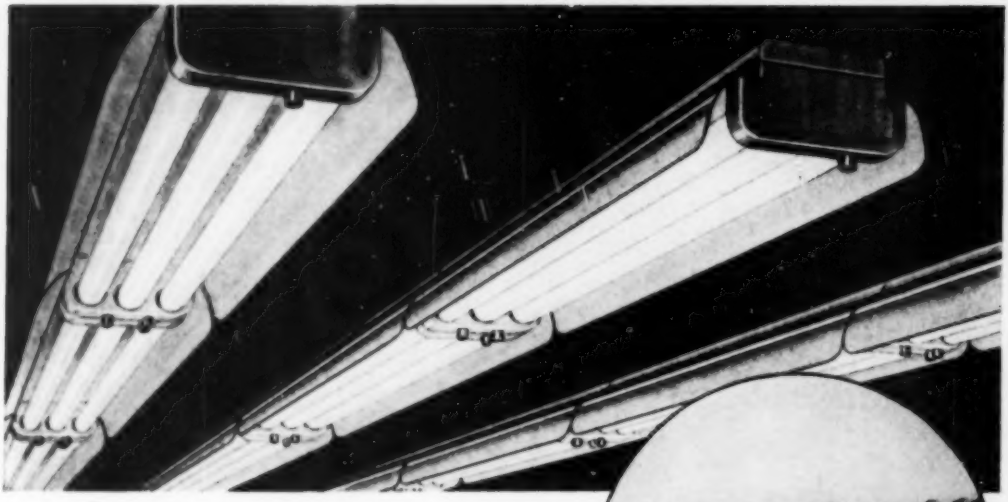


CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

For Continuous Lighting



For Slimline or Standard Fluorescent Lamps

Turret* Lampholders

Trim, straightline installations are a cinch when fixtures are equipped with G-E Turret lampholders. Flat backs of Turret lampholders butt perfectly—leave no gaps—help maintain a straight line during installation. Gleaming white finish actually reflects light instead of presenting a dark space between lamps.

Insist on fixtures with G-E Turret lampholders for all continuous lighting installations. For information on Turrets, see your local G-E accessory equipment representative, or write Section Q10E-887, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

. . . and, for easy one-hand relamping, G-E Turret lampholders offer this easy method for all types of installations.

TO RELAMP, JUST:

1. **Push lamp against spring-backed socket.**
2. **Swing lamp up, it slides into position.**

**Registered Trade-mark, General Electric Company*

You can put your confidence in—

GENERAL ELECTRIC

Equity Savings & Loan Company, Cleveland, Ohio. The main office and three private offices are lighted by Wakefield Ceilings, incorporating PLEXIGLAS diffusers. Architects: Dalton-Dalton Associates, Cleveland. Installed by Parker Electric Company, Cleveland. Wakefield Ceilings are produced by The F. W. Wakefield Brass Company, Vermilion, Ohio.

Lighting . . . Air Diffusion . . . Sound Control . . .

Combined in a Luminous Ceiling

The Wakefield Ceiling shown above, with its corrugated PLEXIGLAS diffusing panels, combines three functions in a single installation.

• Mounted wall to wall beneath fluorescent tubes, the acrylic plastic panels provide high level, low brightness, evenly diffused illumination.

• Conditioned air from the space above the luminous ceiling is delivered into the room through the openings at the edges of the corrugated diffusers. The multiple openings insure an even distribution of air, with elimination of drafts on customers and employees.

• The simple framework for the PLEXIGLAS also supports acoustical baffles which absorb sounds from the work area.

This Wakefield method of combining air diffusion and sound control with the *best* in lighting—using PLEXIGLAS acrylic plastic—can reduce building construction and operation costs. In addition there is the advantage of duct-free, fixture-free appearance.

We will be glad to send you details about the installation shown above, and tell you how PLEXIGLAS may solve *your* lighting problem.

CHEMICALS FOR INDUSTRY

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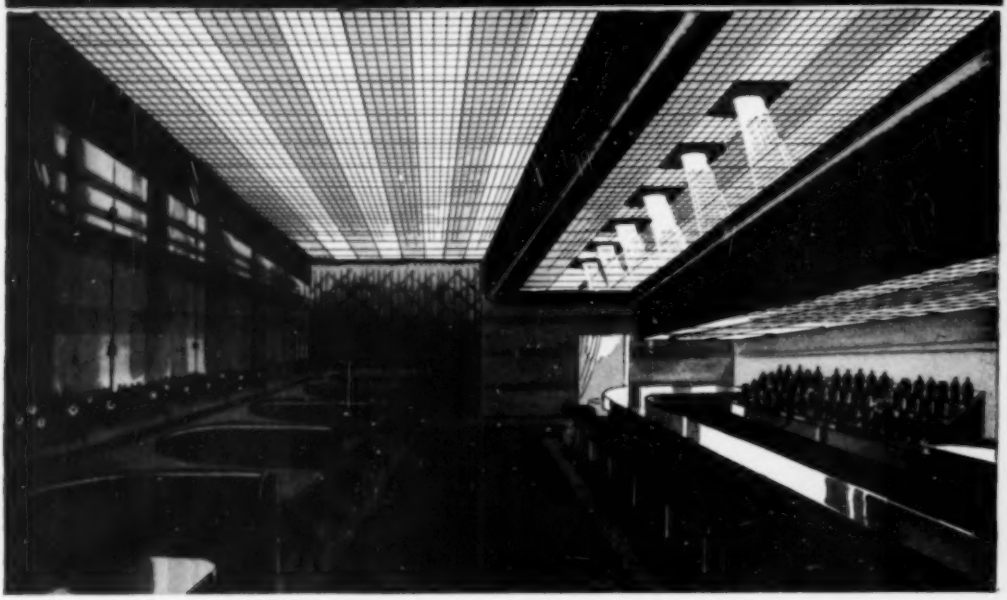
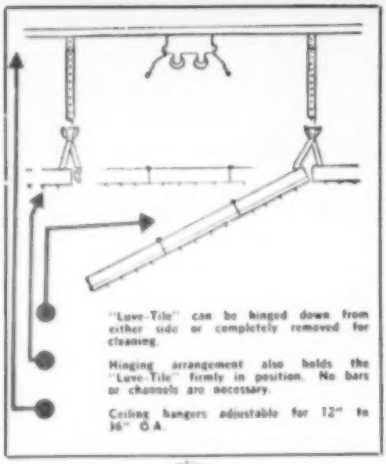
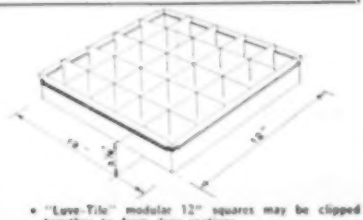
Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

PLEXIGLAS *is a trademark, Reg. U. S. Pat. Off. and other principal countries in the Western Hemisphere.*

Wilson "Luve-Tile"




"Luve-Tile" can be hinged down from either side or completely removed for cleaning.
Hinging arrangement also holds the "Luve-Tile" firmly in position. No bars or channels are necessary.
Ceiling hangers adjustable for 12" to 36" O.A.



• "Luve-Tile" modular 12" squares may be clipped together to form door sections.

THE BEAUTIFUL NEW ILLUMINATED CEILING

• Wilson "Luve-Tile" presents to engineers and design-conscious people the practical tool to ideal lighting. The basic unit consists of a one foot square louvered panel, moulded from Monsanto styrene plastic. Each panel weighs 13 ounces and contains 25 cubes which provide 45° lengthwise and crosswise shielding. Luve-Tile ceilings provide lower ceiling brightness, especially for higher intensities, from 50-foot candles up.

• Luve-Tile is available in white, pastel pink and blue and as such a variety of interesting and practical coloured ceiling patterns are possible. A variation of the pattern effects may be obtained by the use of coloured lights.

• A simple hinging arrangement as illustrated provides easy maintenance. Dirt collection is less rapid or noticeable than with other types of luminous ceilings. Luve-Tile is rigid to handle, light in weight, and simple to remove and wash.

For complete details and prices, write for illustrated catalogue.

J. A. WILSON LIGHTING & DISPLAY INC.

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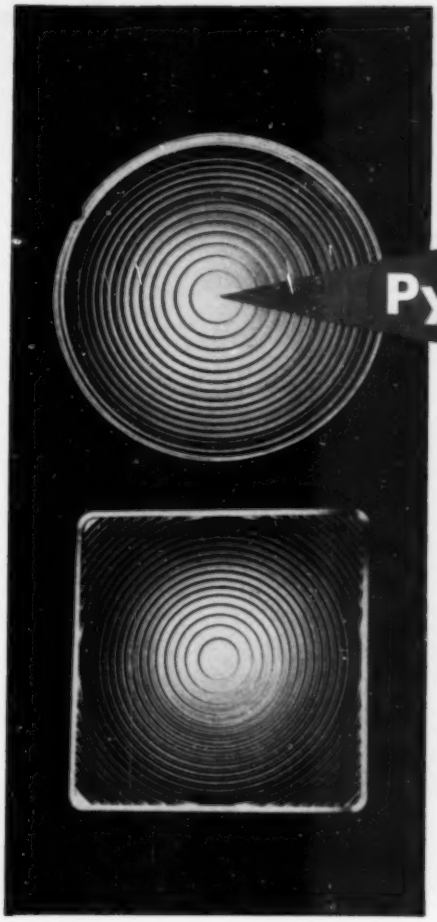

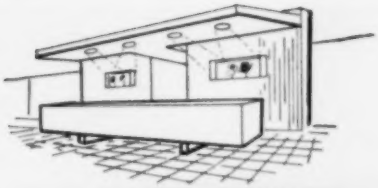

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give you **unusual design flexibility**

For a variety of distinctive lighting effects at low cost—plan on using PYREX brand LENSLITES. They offer a highly flexible medium for control of incandescent light sources. Wide variations in light distribution can be obtained simply by changing the position of the lamp and reflector relative to the LENSLITE, or by using various distribution patterns in the glass itself.

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APPLICATION SUGGESTIONS—Used in recessed ceiling fixtures with the lamp at focal length, with concentrating pattern, LENSLITES provide high intensity concentrated beams for accent lighting in stores, restaurants, etc.

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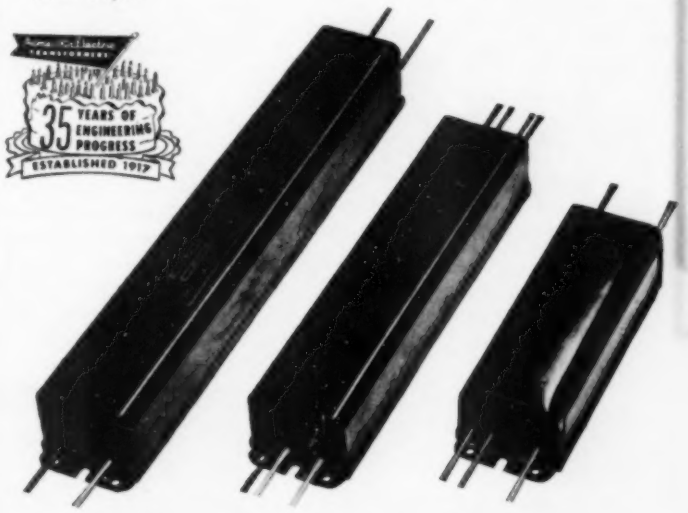

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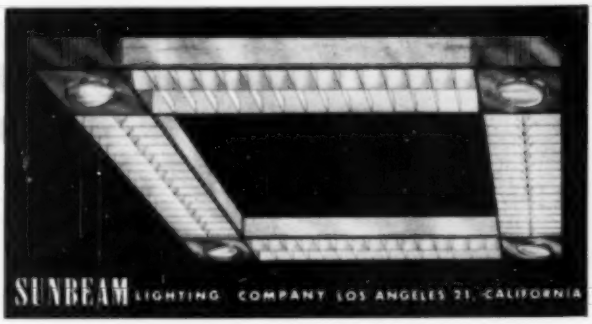

SUNBEAM LIGHTING COMPANY LOS ANGELES 21, CALIFORNIA

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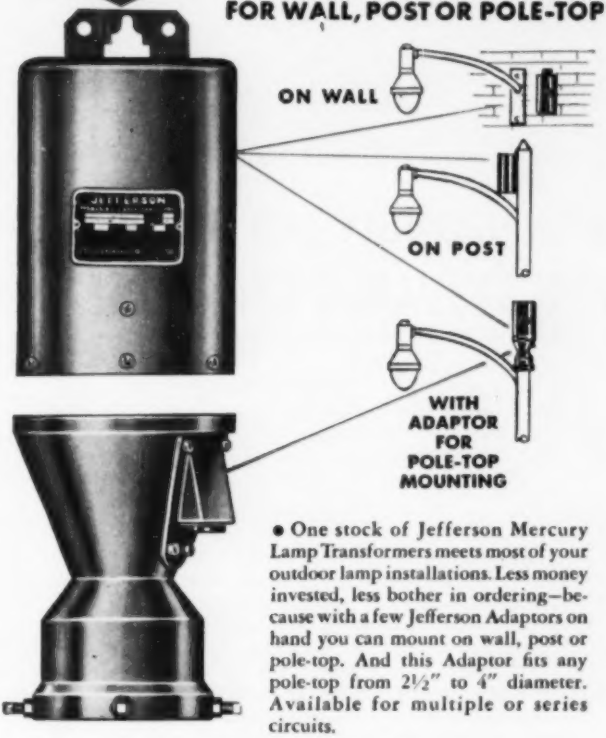

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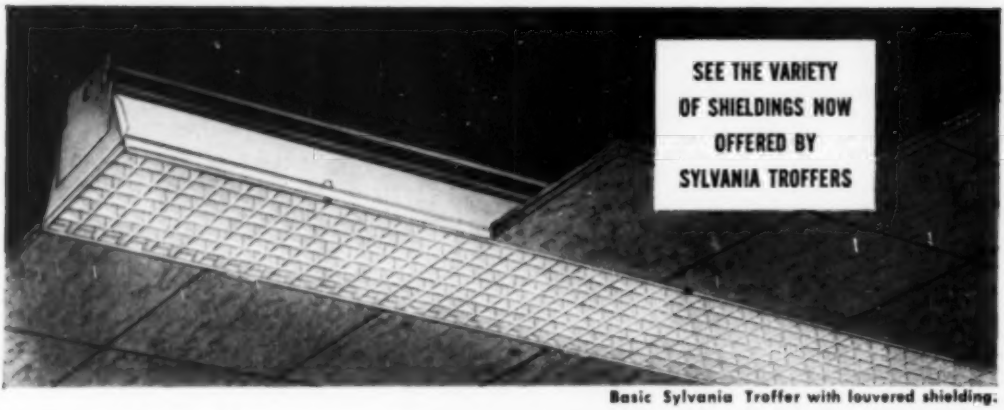

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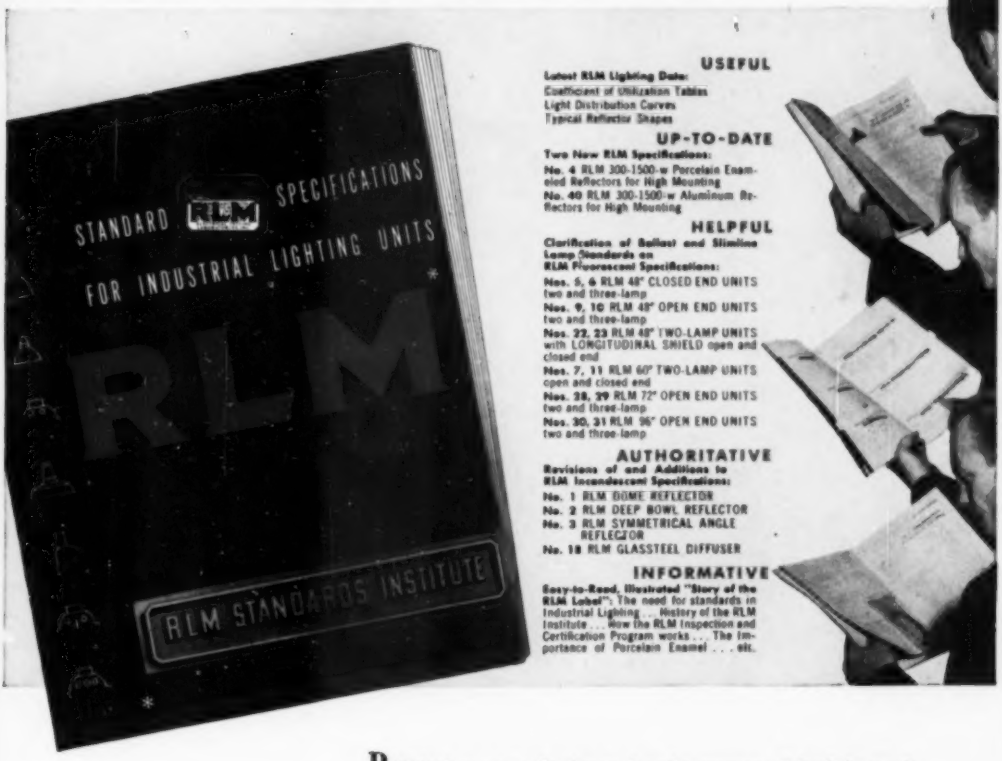
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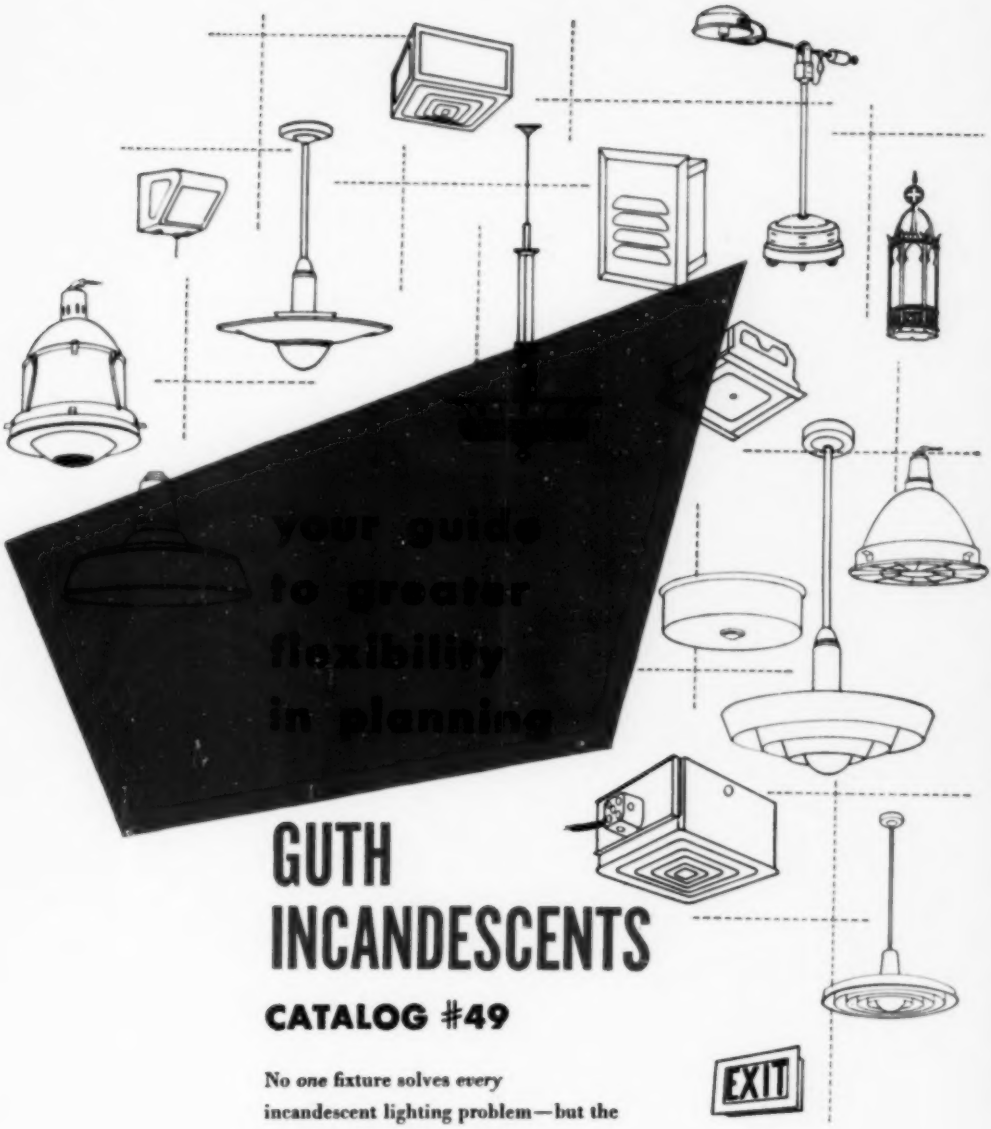

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